AD-A165 352 ADA (TRADEMARK) TRAINING CURRICULUM: ADA TECHNICAL OVERVIEW L102 TEACHER'S GUIDE(U) SOFTECH INC WALTHAM MA 1986 DAAB07-83-C-K506 1/3

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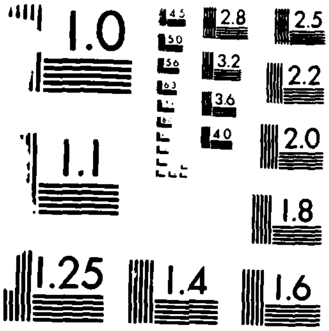

MICROCOPY RESOLUTION TEST CHART
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1986

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Ada® Training Curriculum

Ada® Technical Overview
L102
Teacher's Guide

Superseded
AD-A141862

U.S. Army Communications-Electronics Command
(CECOM)

Contract DAAB07-83-C-K506

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INSTRUCTOR NOTES

THE OBJECTIVE OF THIS MODULE IS TO PROVIDE AN INTRODUCTION TO THE ADA LANGUAGE. THE STUDENT SHOULD GAIN A BEGINNER'S READING KNOWLEDGE OF ADA AND A GOOD FOUNDATION FOR CONTINUED LEARNING. NOTE: THIS MODULE DOES NOT TEACH ADA, BUT TEACHES ABOUT ADA.

BRIEFLY GIVE AN OVERVIEW OF WHAT WILL BE COVERED IN THE MODULE. THE APPROACH IS LEARNING ABOUT ADA THROUGH ADA EXAMPLES. SYNTAX IS NOT STRESSED OR EVEN COVERED. THIS MATERIAL IS FOR OTHER MODULES OF THE CURRICULUM. TELL THE STUDENTS THAT LEARNING ADA IS AN ITERATIVE PROCESS: THEY LEARN SOME, USE IT, AND LEARN SOME MORE. THUS IT IS NOT IMPERATIVE THAT THEY GRASP ALL THE FINE DETAILS. THEY SHOULD AIM FOR THE CONCEPTS AND INTUITIVE "FEEL" OF THE LANGUAGE.

ADA TECHNICAL OVERVIEW

INSTRUCTOR NOTES

THIS SECTION SETS THE HISTORICAL MOTIVATION FOR DoD AND THE RESULTING ADA EFFORT. IT ALSO OUTLINES ITS DEVELOPMENT HISTORY.

ALLOW 60 MINUTES FOR THIS SECTION.

Section 1

Background and Rationale for Ada

INSTRUCTOR NOTES

TOPIC OUTLINE

BACKGROUND AND RATIONALE FOR ADA

WRITING AN ADA PROGRAM FROM BEGIN TO END

SUMMARY OF ADA PROGRAM STRUCTURE

ADA THROUGH EXAMPLE

LARGE SYSTEM DEVELOPMENT

SUMMARY OF ADA FEATURES

FOR MORE INFORMATION

INSTRUCTOR NOTES

A LIST THAT CHARACTERIZES THE PRESENT STATE OF SOFTWARE DEVELOPED FOR EMBEDDED COMPUTER SYSTEMS.

SOFTWARE CRISIS: MOTIVATION FOR ADA

SOFTWARE FOR COMPLEX MILITARY SYSTEMS

- IS USUALLY LATE
- COSTS MORE THAN ORIGINALLY ESTIMATED
- DOES NOT WORK TO ORIGINAL SPECIFICATIONS
- IS UNRELIABLE
- IS DIFFICULT AND COSTLY TO MAINTAIN

INSTRUCTOR NOTES

FOLLOWING ARE SEVERAL GRAPHS AND A LIST OF UNDERLYING PROBLEMS ASSOCIATED WITH THIS "SOFTWARE CRISIS"

BRIEFLY GO THROUGH THESE.

PROBLEMS ASSOCIATED WITH THE SOFTWARE CRISIS

INSTRUCTOR NOTES

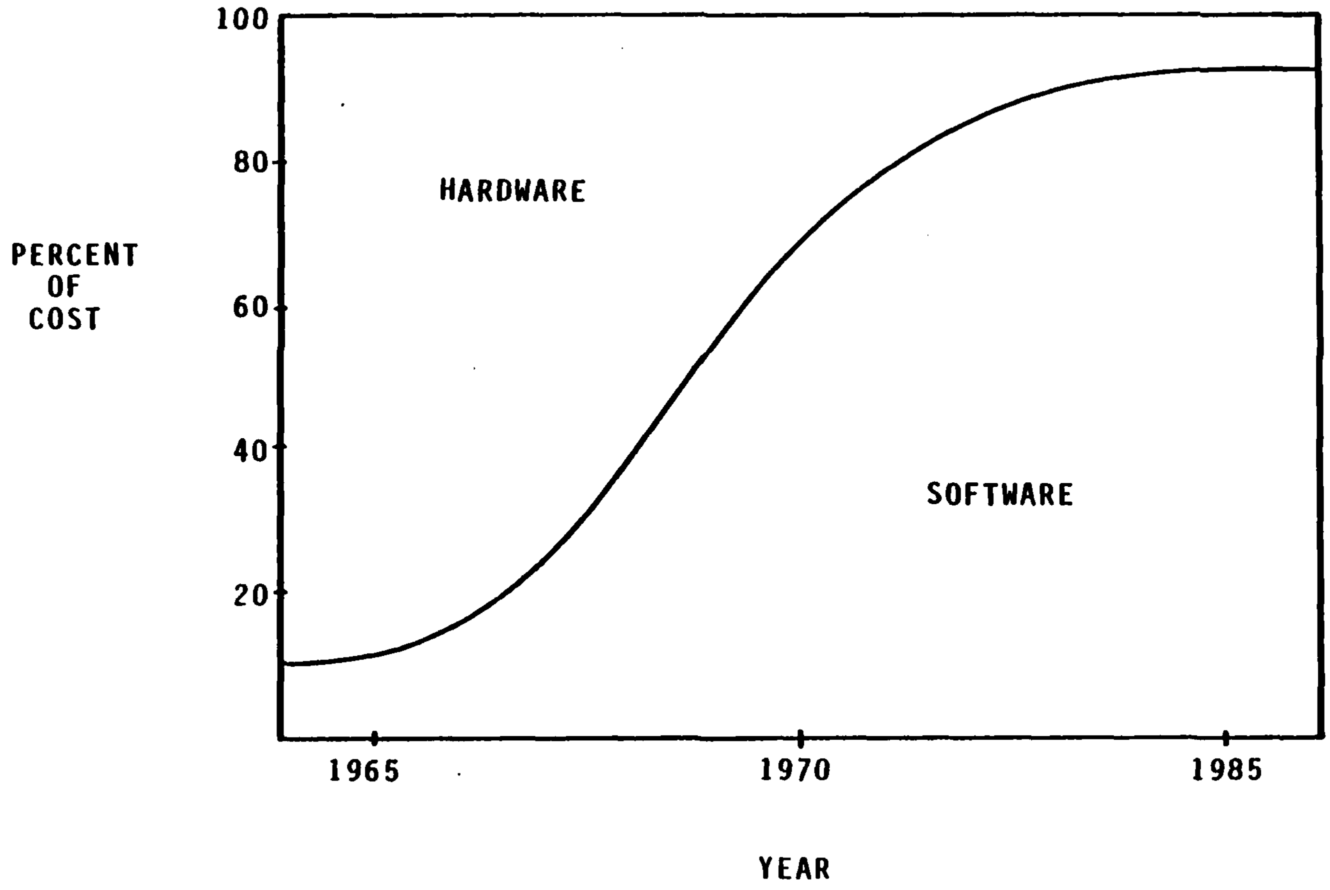
IN 1965, COST OF DEVELOPING A SOFTWARE SYSTEM WAS PRIMARILY A HARDWARE COST.

AROUND 1970 THIS BREAKDOWN OF TOTAL COST OF A SYSTEM WAS SPLIT FAIRLY EVENLY BETWEEN HARDWARE AND SOFTWARE.

BUT SINCE THEN, SOFTWARE COSTS FOR A SYSTEM HAVE RISEN DRAMATICALLY WHILE HARDWARE COSTS HAVE PLUMMETED AS A RESULT OF MICRO-CHIP TECHNOLOGICAL ADVANCES.

SOURCE: BARRY BOEHM, DEC 1976, IEEE TRANSACTIONS.

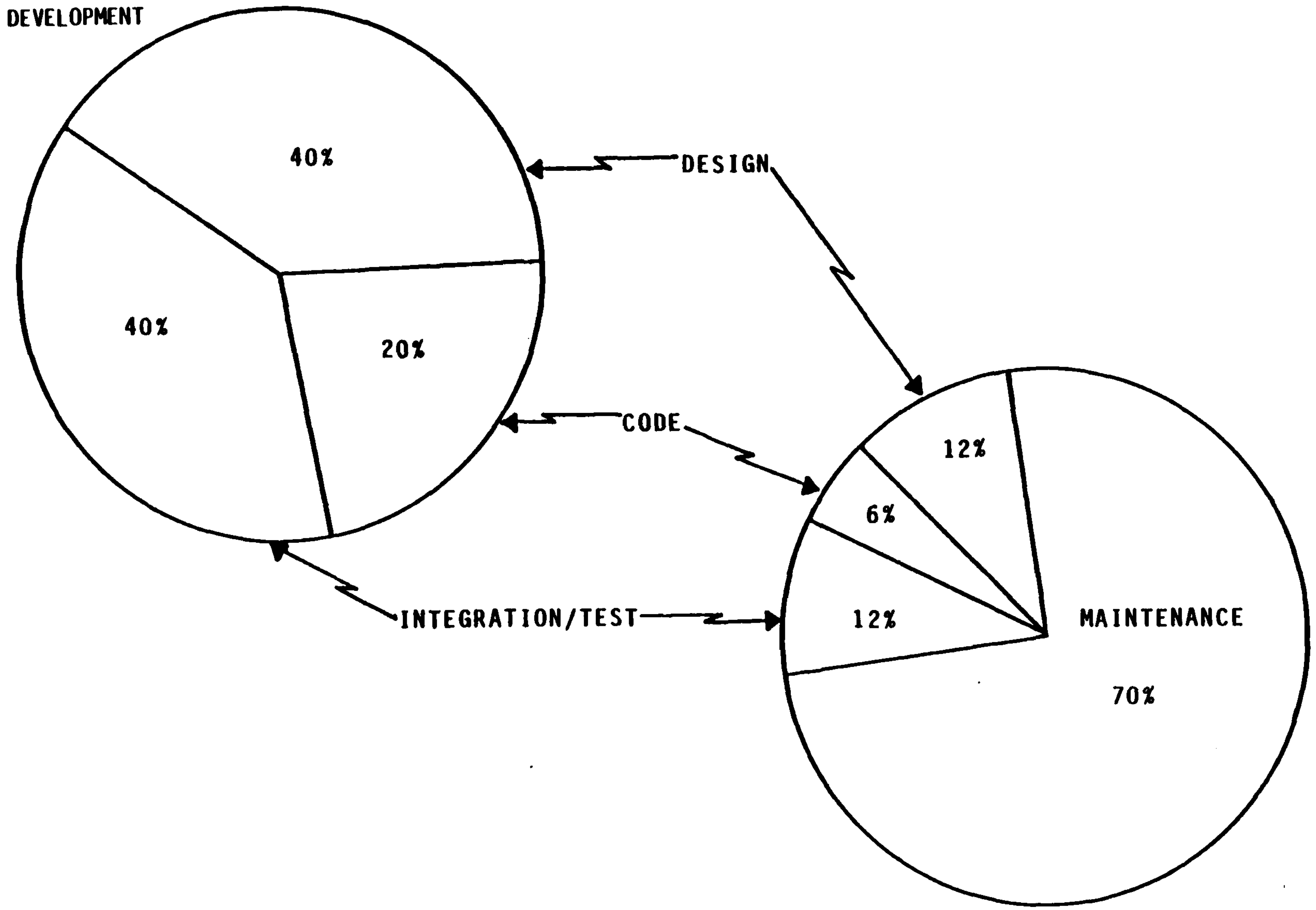
SOFTWARE COSTS INCREASING AS HARDWARE COSTS DECREASING



INSTRUCTOR NOTES

THE CAUSE OF THE INCREASED SOFTWARE COSTS IS THE SPECIFIC COST OF MAINTAINING/UPGRADING A SYSTEM ONCE IT IS OPERATIONAL.

SOFTWARE MAINTENANCE NEARLY TRIPLE ORIGINAL DEVELOPMENT COSTS



INSTRUCTOR NOTES

AN ADDITIONAL COST WITH SOFTWARE LIES IN ERROR DETECTION AND CORRECTION.

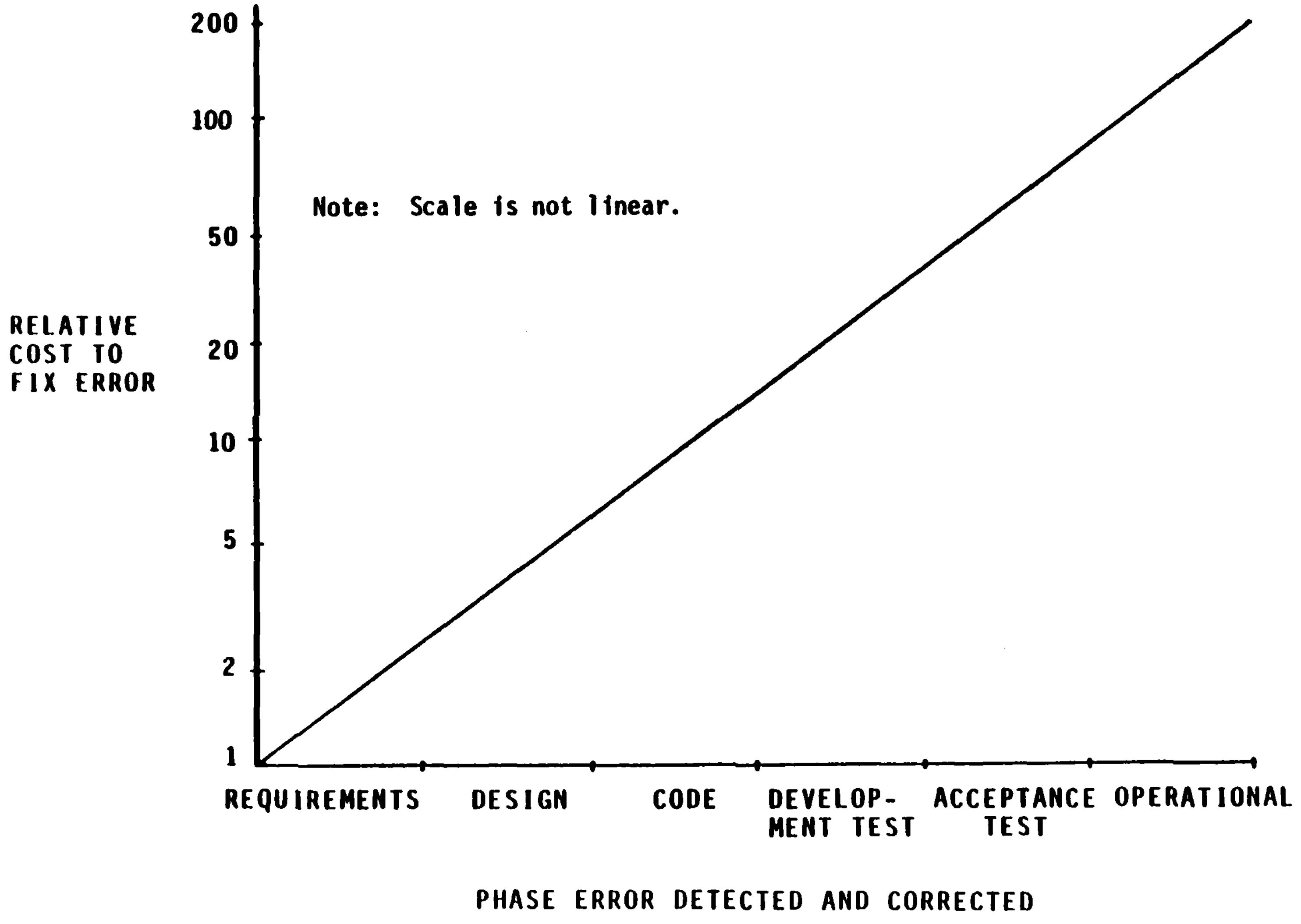
FOR EXAMPLE:

- IF A REQUIREMENTS ERROR IS FOUND AND CORRECTED DURING THE REQUIREMENTS PHASE, YOU CAN JUST CORRECT THE REQUIREMENTS DOCUMENT WITH LITTLE COST IMPACT OF THE ERROR.

IF THE SAME ERROR IS NOT FOUND AND CORRECTED UNTIL MAINTENANCE, THE CORRECTION INVOLVES NOT ONLY DOCUMENT CHANGES SUCH AS SPECIFICATIONS, USER MANUALS, TRAINING MANUALS, BUT WILL ALSO INVOLVE VARIOUS AMOUNTS OF CODE MODIFICATIONS AND REVALIDATION. ERROR CORRECTION AT THIS POINT IN THE LIFE CYCLE IS TYPICALLY 100 TIMES WHAT IT WOULD HAVE BEEN IN THE REQUIREMENTS PHASE. THUS UPDATING DOCUMENTATION BECOMES A MAJOR COST FACTOR.

SOURCE: B. BOEHM, SOFTWARE ENGINEERING ECONOMICS, 1981
DATA IS FROM STUDIES BY IBM, TRW, GTE ON THIS TOPIC

COST OF ERROR CORRECTION



Note: Scale is not linear.

INSTRUCTOR NOTES

OTHER ASSOCIATED PROBLEMS WITH DECREASED PRODUCTIVITY AND RELIABILITY OF OUR SOFTWARE ARE THAT THE PROBLEMS WE ARE ATTEMPTING TO SOLVE NOW ARE MUCH MORE COMPLEX THAN IN THE PAST. COMPLEXITY ALONE IS NOT A PROBLEM, IT'S THE LACK OF ADEQUATE TOOLS TO ASSIST.

ADDITIONAL PROBLEMS

- SOFTWARE TASKS ARE MORE COMPLEX NOW, BUT NO ADEQUATE TOOLS TO DEAL WITH THE PROBLEM

- SUPPORT TOOLS (ASSEMBLERS, LINKERS, DEBUGGER) MUST BE DEVELOPED FOR EACH LANGUAGE AND MACHINE

- LACK OF ADEQUATE MANAGEMENT <u>AND</u> SOFTWARE DEVELOPMENT TOOLS

INSTRUCTOR NOTES

AS ARCHITECTURES HAVE PROLIFERATED, SO TOO HAVE LANGUAGES. PLUS THE SUPPORT TOOLS FOR EACH ARCHITECTURE/LANGUAGE COMBINATION MUST BE DEVELOPED ANEW. OUR CURRENT LANGUAGES ARE NOT WELL SUITED TO THE NEEDS OF EMBEDDED COMPUTER SYSTEMS.

ADDITIONAL PROBLEMS (Continued)

- SOFTWARE IS NOT REUSABLE ON DIFFERENT SYSTEMS
- PROLIFERATION OF LANGUAGES AND ARCHITECTURES
- LANGUAGES NOT SUITED FOR CURRENT APPLICATION
- SUPPLY OF QUALITY SOFTWARE PERSONNEL NOT ABLE TO MEET CURRENT SOFTWARE DEMANDS

INSTRUCTOR NOTES

IT IS A RETHINKING OF THE WAY IN WHICH SOFTWARE SYSTEMS WILL BE DEVELOPED IN THE FUTURE WITH THE ITEMS LISTED AS VEHICLES OF THAT CHANGE. NOTE THAT IT IS THE COMBINATION OF LANGUAGE, ENVIRONMENT, AND METHODOLOGIES THAT CONSTITUTES THE ADA EFFORT.

WHEN WE SPEAK OF MODERN SOFTWARE ENGINEERING METHODS, WE ARE REFERRING TO SUCH THINGS AS STRUCTURED DESIGN AND PROGRAMMING, TOP-DOWN DEVELOPMENT, STRONG DATA TYPING, MODULARITY.

RELIABLE SOFTWARE IMPLIES THAT THE SOFTWARE PRODUCT CAN RECOVER FROM ERROR OR FAILURE CONDITIONS IN OPERATION AS WELL AS PREVENT ERRORS IN ANALYSIS, DESIGN, AND CODE IMPLEMENTATION.

MAINTAINABLE SOFTWARE IMPLIES THAT OUR SOFTWARE PRODUCT HAS BEEN CONSTRUCTED SUCH THAT THE STRUCTURE AND ORGANIZATION OF THE SYSTEM ARE CLEAR AND MODIFICATION TO THE SYSTEM CAN BE DONE WITH RELATIVE EASE (SUCH THAT CHANGES DO NOT CAUSE NEW ERRORS).

COST REDUCTION OCCURS ONLY OVER THE LIFE OF THE PRODUCT. WE ARE PRIMARILY CONCERNED WITH PROJECTS OF LONG DURATION WHICH WILL BE MODIFIED AND ENHANCED CONTINUALLY. THERE IS NO COST SAVINGS DURING DEVELOPMENT.

THE ADA EFFORT: DoD's RESPONSE

THROUGH A COMBINATION OF:

- MODERN SOFTWARE ENGINEERING METHODS
- COMMON HIGH ORDER LANGUAGE (ADA)
- COMMON SUPPORT TOOLS (ADA PROGRAMMING SUPPORT ENVIRONMENT - APSE)

DEVELOP SOFTWARE THAT IS:

- RELIABLE
- MAINTAINABLE
- LESS COSTLY OVER THE LIFE CYCLE
- PORTABLE

INSTRUCTOR NOTES

THE APPROACH TO THE ADA DESIGN WAS INNOVATIVE. A LIFE-CYCLE APPROACH WAS TAKEN. THE ADA LANGUAGE CAN BE VIEWED AS A PRODUCT LIKE BUILDING A MISSILE: FROM ANALYSIS OF A PROBLEM AND POSSIBLE SOLUTION, THROUGH REQUIREMENTS (IN THE SERIES OF LANGUAGE REQUIREMENT SPECS), TO OPERATIONAL (WITH ACTUAL COMPILER DEVELOPMENT AND VALIDATION).

IMPORTANT TO NOTE THAT THROUGHOUT THE PROCESS, UNIVERSITIES, INDUSTRY AND COMPILER IMPLEMENTORS WERE SOLICITED FOR INPUT (REVIEWS, OPINIONS).

DEVELOPMENT OF ADA LANGUAGE

ANALYSIS	1970-1975	IDENTIFICATION OF SOFTWARE PROBLEMS IN EMBEDDED MILITARY SYSTEMS (THE CRISIS) STRAWMAN, WOODENMAN, TINMAN LANGUAGE REQUIREMENTS SPECIFICATIONS
REQUIREMENTS	1975-1977	HOLWG: HOL REQUIREMENTS FOR EMBEDDED SYSTEMS DEFINED EXISTING LANGUAGES EVALUATED RESULTS: ONE LANGUAGE IS SUFFICIENT NO EXISTING LANGUAGE SATISFIES ALL REQUIREMENTS AN EXISTING LANGUAGE SHOULD BE USED AS A BASE
DESIGN		
PHASE I	1977-1978	PRELIMINARY LANGUAGE DESIGN - IRONMAN (RED, BLUE, YELLOW, GREEN)
PHASE II	1978-1979	FORMAL LANGUAGE DEFINITION - STEELMAN (RED, GREEN)
PHASE III	1979-1980	FINAL LANGUAGE DEFINITION BY CII HONEYWELL/BULL

INSTRUCTOR NOTES

COMPILER VALIDATION INSTITUTED TO RESTRICT THE PROLIFERATION OF ADA DIALECTS. ADA COMPILERS MUST BE VALIDATED YEARLY AND IF A NEW VERSION IS RELEASED BY THE ADA VALIDATION OFFICE (PART OF THE ADA JOINT PROGRAM OFFICE-AJPO).

PARALLEL PROJECTS ALLOW FOR AN ORGANIZATION TO TRANSITION METHODICALLY TO ADA BY DOING A PARTICULAR PROJECT IN ADA AND IN THE FORMER LANGUAGE AND METHODS. THUS EXPERIENCE INTO ADA METHODS CAN BE EXPLORED WITHOUT IMPACT TO THE END PRODUCT.

DR. DELAUER'S PROCLAMATION MANDATES THE USE OF ADA ON ALL NEW CONTRACTS AS OF 1 JAN 84.

THE TOTAL NUMBER OF VALIDATED COMPILERS COVERS 11 VENDORS AND MANY COMBINATIONS OF HOST AND TARGET COMPUTERS. THERE ARE 4 VAX 11/750 SYSTEMS AND 7 VAX 11/780, 782, 785 SYSTEMS, TO NAME THE MOST COMMON COMPUTER.

LANGUAGE DEVELOPMENT (Continued)

TESTING	1980-1982	LANGUAGE REFINEMENT BY INTERNATIONAL REVIEWERS
		COMPILER VALIDATION TEST FACILITY
		ANSI STANDARDIZATION REQUESTED
OPERATIONAL	1982 →	COMPILER DEVELOPMENT BY DoD, PRIVATE INDUSTRY, ACADEMIA
		PARALLEL PROJECTS
	FEB. 1983	ANSI STANDARDIZATION OF ADA LANGUAGE
	MAR. 1983	NYU (ADA/ED) VALIDATED TRANSLATOR
	JUN. 1983	ROLM VALIDATED COMPILER
		DR. DELAUER'S PROCLAMATION
	DEC. 1984	SOFTECH ALS VALIDATED
	OCT. 1985	35 VALIDATED COMPILERS

INSTRUCTOR NOTES

WHAT DO WE MEAN BY ENVIRONMENTS IN GENERAL.

ENVIRONMENTS

- PROVIDE A SET OF AUTOMATED TOOLS TO AID SOFTWARE DEVELOPERS AT VARIOUS PHASES IN THE LIFE CYCLE

  EXAMPLES: COMPILERS
  LINKERS
  LOADERS
  CODE AUDITORS
  PROGRAMMING SUPPORT LIBRARIES

- CURRENT SITUATION WITH ENVIRONMENTS

  MUST BE DEVELOPED FOR EACH MACHINE

  PERSONNEL MUST LEARN A NEW SET OF TOOLS FOR EACH MACHINE

  LIMITED TOOL SETS AVAILABLE

SPECIFICALLY ADA ENVIRONMENTS.

THE APSE WAS INTENDED TO BE HOSTED ON ONE PHYSICAL MACHINE (GENERALLY A SIZABLE MAINFRAME) WITH THE TARGET MACHINE OF THE DEVELOPMENT PROBABLY A MUCH SMALLER COMPUTER (WHICH WOULD NOT HAVE THE ADDRESS SPACE/PERIPHERALS NECESSARY).

THE DATABASE OF THE APSE IS AN IMPORTANT FEATURE. IT HOUSES ALL PROJECT SOURCE CODE, OBJECT CODE, AND DOCUMENTATION.

ADA ENVIRONMENTS

- GOAL IS TO PROVIDE AUTOMATED TOOL SUPPORT FOR ALL PROJECT PERSONNEL INVOLVED IN MANAGING, DEVELOPING, AND MAINTAINING SOFTWARE SYSTEMS

- INCLUDES TOOLS FOR ALL PHASES OF LIFE CYCLE

- ADVANTAGES

    TOOL DEVELOPMENT COSTS REDUCED

    PORTABILITY OF TOOLS, SOFTWARE, PROGRAMMERS

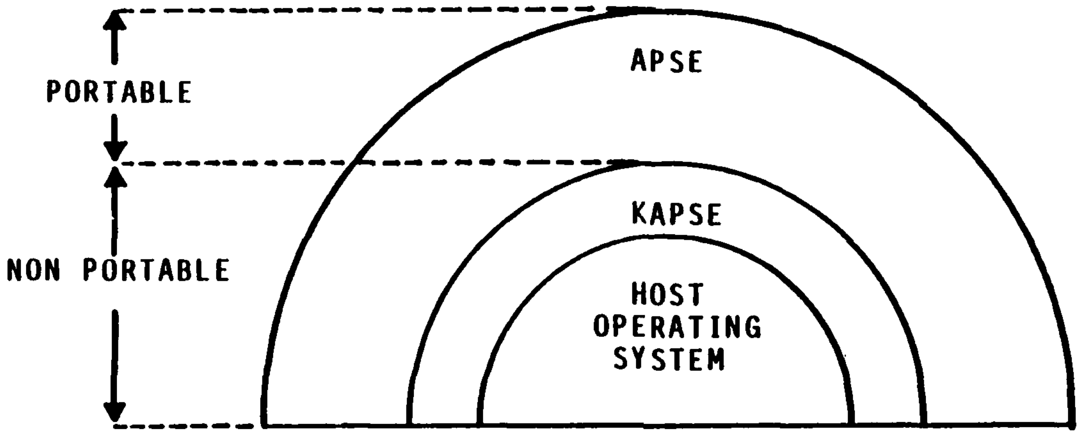
    CAN BE USED THROUGHOUT THE LIFE CYCLE

- PORTABILITY ACHIEVED THROUGH A LOW-LEVEL INTERFACE TO THE HOST OPERATING SYSTEM (THE KAPSE) AND A SET OF TOOLS (THE APSE)

INSTRUCTOR NOTES

CONCEPTUALLY THE STRUCTURE IS IN NESTED LEVELS. AT THE INNER MOST LEVEL IN THE OPERATING SYSTEM IS THE PHYSICAL DATABASE. ABOVE IT, IS THE KAPSE WHICH TAKES CARE OF ALL PHYSICAL TO LOGICAL INTERFACES OF THE ENTIRE APSE. ABOVE THE KAPSE, THE APSE SITS. IT CONTAINS TOOLS NECESSARY TO AID SOFTWARE DEVELOPMENT THROUGHOUT THE LIFE CYCLE.

ADA ENVIRONMENT STRUCTURE



KAPSE:	KERNEL ADA PROGRAMMING SUPPORT ENVIRONMENT
APSE:	ADA PROGRAMMING SUPPORT ENVIRONMENT

INSTRUCTOR NOTES

WHAT IS IN EACH PART OF APSE:

KAPSE: NO EXPLICIT TOOLS BUT SUPPORTS -

DATABASE ACCESS

I/O

TERMINAL TO TOOL ACCESS

RUNTIME SYSTEM

APSE: TOOLS INCLUDE:

COMPILERS

LOADERS

LINKERS

TEXT EDITOR

SYMBOLIC DEBUGGERS

COMMAND INTERPRETER

FILE ADMINISTRATOR TOOLS

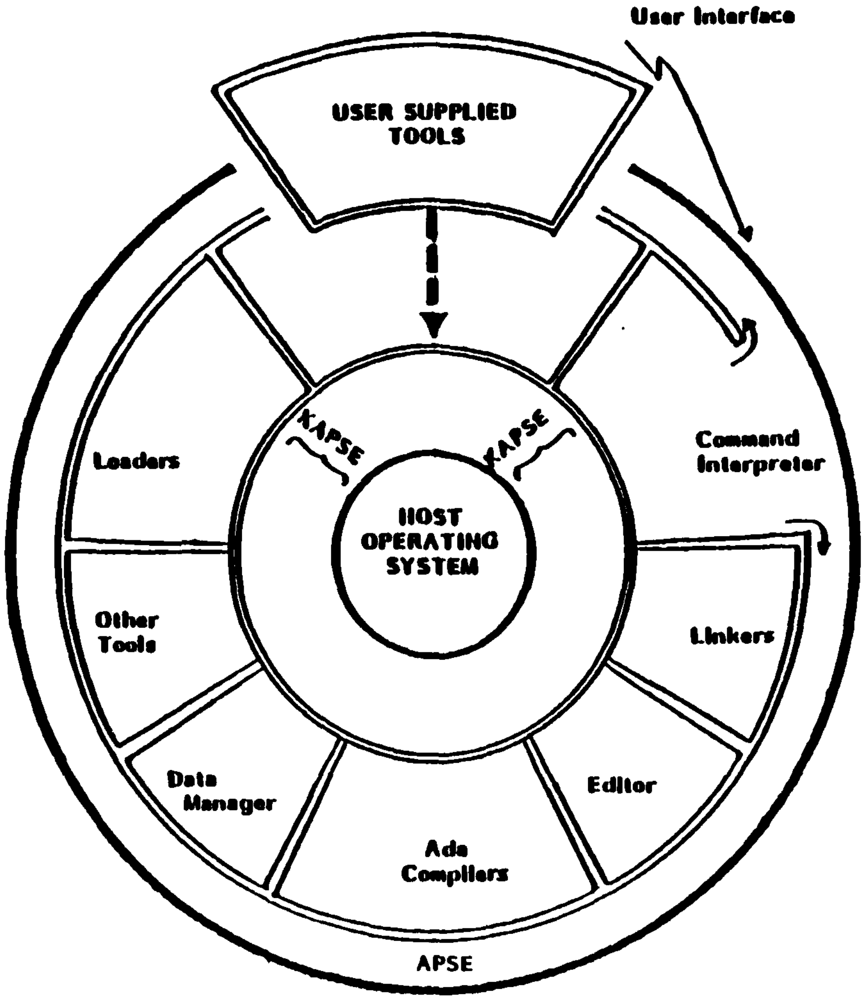
CONFIGURATION MANAGEMENT TOOLS

THE KAPSE SHOULD CONTAIN ALL LOW-LEVEL FEATURES NECESSARY TO REHOST ONTO ANOTHER SYSTEM.

INSTRUCTOR NOTES

THIS IS THE COMMON PICTURE OF THE APSE STRUCTURE THAT THE STUDENT WILL SEE.

APSE STRUCTURE



INSTRUCTOR NOTES

SIMILAR FORMAT AS THE LANGUAGE.

OF NOTE: THE SPECIFICATION FOR THE ENVIRONMENTS IS NOT AS RIGOROUS AS FOR THE LANGUAGE SINCE WE KNOW LESS OF WHAT SHOULD BE IN AN ENVIRONMENT.

MAIN ENVIRONMENT PROJECTS : ALS (ADA LANGUAGE SYSTEM)
AIE (ADA INTEGRATED ENVIRONMENT)

- IN 1985, AIE WAS DOWNGRADED TO ACS (ADA COMPILATION SYSTEM)

DEVELOPMENT OF ADA ENVIRONMENTS

ANALYSIS	1977-1978	LANGUAGE ALONE NOT SUFFICIENT TO IMPROVE SOFTWARE DEVELOPMENT
REQUIREMENTS	1978-1979	PRELIMINARY ENVIRONMENT REQUIREMENTS (SANDMAN, PEBBLEMAN)
DESIGN	1980	FORMAL ENVIRONMENT DEFINITION (STONEMAN)
IMPLEMENTATION	1981 →	COMPILER PLUS ENVIRONMENT DEVELOPMENT PROJECTS FUNDED BY DoD, PRIVATE INDUSTRY, UNIVERSITIES
TESTING	1982 →	KAPSE INTERFACE TEAM (KIT) FOR INDUSTRY AND ACADEMIA (KITIA): TASK IS TO DEFINE STANDARD INTERFACES FOR ALS AND AIE
OPERATIONAL/ MAINTENANCE	1983 →	

INSTRUCTOR NOTES

THIS RELATES THE ADA EFFORT TO OUR ORIGINAL PROBLEM. HOW OR WHY EACH PART OF THE EFFORT IS USEFUL IN ATTEMPTING TO MANAGE OUR SOFTWARE PROBLEMS. IN THIS PERSPECTIVE, ADA IS NOT JUST A LANGUAGE, BUT BECOMES A TOOL - LIKE LINKERS, DEBUGGERS, METHODOLOGIES - TO DEAL WITH SOFTWARE DEVELOPMENT PROBLEMS.

RELIABILITY AND MAINTAINABILITY ARE INCREASED THROUGH MODERN SOFTWARE ENGINEERING PRINCIPLES AND METHODS SUCH AS STRUCTURED DESIGN AND PROGRAMMING (WHICH ALSO HELP INCREASE PRODUCTIVITY), MODULARITY, STRONG TYPING AND ERROR RECOVERY MECHANISMS.

THE ADA EFFORT AND THE SOFTWARE CRISIS

- MODERN SOFTWARE ENGINEERING METHODS
  - INCREASED PRODUCTIVITY
  - INCREASED RELIABILITY, MAINTAINABILITY
- COMMON HIGH ORDER LANGUAGE
  - DESIGNED TO SUPPORT MODERN SOFTWARE DEVELOPMENT METHODS
  - SUPPORTS THE MANAGEMENT OF COMPLEXITY AND CHANGING REQUIREMENTS
  - REDUCED PROGRAMMER RETRAINING
- COMMON SUPPORT ENVIRONMENT
  - REDUCED COST OF WRITING CUSTOMIZED SYSTEMS PROGRAMS
  - INCREASED PORTABILITY OF SOFTWARE/PROGRAMMERS
  - LIFE CYCLE SUPPORT OF SOFTWARE DEVELOPMENT
  - REDUCED PROGRAMMER RETRAINING

INSTRUCTOR NOTES

THIS SECTION PROVIDES AN OVERVIEW (CONCEPTUAL, INTUITIVE FEEL) OF PROGRAMMING IN ADA, FROM PROBLEM DEFINTION TO MAINTENANCE.

STRESS TO THE STUDENTS THAT SYNTAX IS NOT THE KEY ISSUE HERE -- OVERALL STRUCTURE AND CONCEPTS IS.

ALLOW 1-1/2 HOURS FOR THIS SECTION. BREAK BEFORE "COMPILATION."

Section 2

Writing an Ada Program from Begin to End

INSTRUCTOR NOTES

TOPIC OUTLINE

BACKGROUND AND RATIONALE FOR ADA

WRITING AN ADA PROGRAM FROM BEGIN TO END

SUMMARY OF ADA PROGRAM STRUCTURE

ADA THROUGH EXAMPLE

LARGE SYSTEM DEVELOPMENT

SUMMARY OF ADA FEATURES

FOR MORE INFORMATION

INSTRUCTOR NOTES

THE PURPOSE OF THE EXAMPLE IS TO ILLUSTRATE WHAT IT'S LIKE TO WRITE AN ADA PROGRAM FROM BEGINNING TO END. THIS GIVES AN APPRECIATION OF THE PROCESS IN ADA. THIS EXAMPLE IS ELEMENTARY BUT BECAUSE OF THAT, THE STUDENT CAN CONCENTRATE ON THE ADA AND NOT THE ALGORITHMS. THE FORMAT IS TO PARALLEL SOFTWARE DEVELOPMENT. FIRST DECOMPOSE THE PROBLEM FROM THE TOP, DOWN THROUGH SPECIFIC ALGORITHMS TO THE CONTROL STRUCTURE LEVEL. AFTER THUS ANALYZING THE PROBLEM, THE ADA CODE IS BUILT FROM THIS POINT BACK UP TO A COMPLETE ADA SYSTEM. THE ADA SYNTAX IS TOTALLY BY EXAMPLE (I.E. OSMOSIS). ADDITIONAL GOALS ARE TO GENERATE A FAMILIARITY WITH ADA, THE EASE WITH WHICH IT CAN BE READ, AND TO CREATE A NON-THREATENING APPRECIATION FOR THE LANGUAGE. TO BUILD THE ADA SYSTEM, WE START FIRST WITH CONTROL STRUCTURES, AS ACTION STATEMENTS IN ADA ARE VERY SIMILAR TO OTHER LANGUAGES. THE STATEMENT CODE FRAGMENTS ARE SIMILAR TO WHAT WILL BE USED IN THE FINAL CODE. IN THIS WAY THE RATIONALE IS SET FOR TYPES AND OBJECTS. NEXT, A LOOK AT TYPE AND OBJECT DECLARATIONS. AGAIN ACTUAL CODE RELATED TO THE EXAMPLE IS USED. CODE COMMENTS PROVIDE EXPLANATIONS OF THE ADA THUS AFTER THE COURSE IS FINISHED, THE STUDENT CAN REFER BACK TO THE COURSE NOTES WITH UNDERSTANDING. THE EXAMPLE NOW BUILDS TO ADA SUBPROGRAMS AND PARAMETERS. AT THIS POINT, THE COMPLETED CODE IS PRESENTED FOR ALL PROCEDURES AND FUNCTIONS. NEXT THESE RESOURCES ARE COLLECTED INTO AN ADA PACKAGE. ADA PROVIDES THE FACILITIES TO CREATE OUR OWN USAGE PACKAGES. THIS BUILDS AN INTUITIVE FEEL FOR THE USEFULNESS OF THE PACKAGE CONCEPT IN ADA. FINALLY, THE MAIN LOGIC PROCEDURE IS PRESENTED WHICH USES THE RESOURCES OF TWO PACKAGES. WITHIN THE MAIN PROCEDURE, A SIMPLE I/O FORMAT IS PRESENTED TO ILLUSTRATE BOTH THE ABILITY TO CREATE ONE'S OWN I/O ROUTINES, SPECIALLY TAILORED, AND TO ALSO SHOW THE USE OF THE 'GET' AND 'PUT' PROCEDURES. AS A WHOLE THE ADA EXAMPLE ILLUSTRATES A BASIC PROGRAM STRUCTURE - I.E. A MAIN DRIVER PROCEDURE USING RESOURCES FROM ONE OR MORE PACKAGES WITH THE PACKAGES IN TURN CONSISTING OF NESTED SUBPROGRAMS. AS PART OF CODING ADA, THE SYSTEM MUST BE COMPILED TO TRANSLATE THE SOURCE TO OBJECT CODE FOR EVENTUAL EXECUTION. COMPILATION AND THE PROGRAM LIBRARY ARE PRESENTED FOLLOWED BY TWO EXAMPLES OF SYSTEM CHANGE.

IT IS CRUCIAL FOR THE INSTRUCTOR TO SET UP THE PURPOSE OF THIS EXAMPLE. OTHERWISE, CONTINUAL SYNTAX QUESTIONS MAY ARISE. (THIS MAY HAPPEN ANYWAY. IF SO, GENTLY REMIND THEM OF THE PURPOSE.)

EXAMPLE 1

A SYSTEM THAT RECORDS AND TRACKS TWO-DIMENSIONAL MOVEMENT ON A RADAR SCREEN NEEDS A PROCEDURE THAT, GIVEN THE LAST POSITION RECORDED, THE CURRENT POSITION, THE TIME BETWEEN THOSE READINGS, AND A NEW TIME INTERVAL, WILL PREDICT WHERE THE NEXT POINT SHOULD OCCUR. THE PREDICTION WILL ASSUME THAT NO CHANGE IN SPEED OR DIRECTION WILL OCCUR; THE VALUE THUS OBTAINED MIGHT LATER BE COMPARED TO THE ACTUAL READING TO DETERMINE PATTERNS OF CHANGE IN EITHER FACTOR. THE TRACKING PROGRAM THUS NEEDS ACCESS TO A NEXT-POINT CALCULATION ROUTINE, WHICH SHOULD BE ASSOCIATED WITH FACILITIES TO CALCULATE THE DISTANCE BETWEEN TWO POINTS AND TO DETERMINE VELOCITY. DUE TO THE SPECIFICS OF THE SYSTEM, A VENDOR-SUPPLIED PACKAGE CONTAINING SUCH ROUTINES WOULD BE UNSUITABLE.

INSTRUCTOR NOTE

OUR EXAMPLE PROCESS

STATEMENT OF REQUIREMENTS (COMPLETED)

DECOMPOSITION OF SOLUTION

ADA IMPLEMENTATION (CODE AND COMPILATION)

CHANGES TO THE SYSTEM

INSTRUCTOR NOTES

FOR THE EXAMPLE WE ARE NOT TRYING TO SHOW THE BEST OR ONLY WAY TO APPROACH THE PROBLEM BUT RATHER TO ILLUSTRATE THE THOUGHT PROCESS INVOLVED IN ADA SYSTEMS.

WE BEGIN AT A HIGH LEVEL OF ABSTRACTION OF THE PROBLEM AND CONTINUE TO DECOMPOSE TO THE STATEMENT LEVEL.

LET US SUMMARIZE THE OBJECTS TO BE DEALT WITH AND THE OPERATIONS NEEDED TO BE PERFORMED RELATIVE TO THE OBJECTS.

A PICTURE OF A SOLUTION IS SHOWN. IT HAS BEEN DECIDED TO HAVE A MAIN PROGRAM WHICH CONTROLS THE OVERALL LOGIC FLOW OF THE SYSTEM. A SMALL PACKAGE WILL IMPLEMENT THE VECTOR CALCULATIONS. THE MAIN PROCEDURE LOGIC IS PRESENTED AS PSEUDO-CODE FOR THE MOMENT. BUT THE POSSIBLE SOLUTION MUST BE FURTHER DECOMPOSED TO MORE FULLY UNDERSTAND THE VECTOR SERVICES.

THE SAME PROCESS WOULD THEN BE DONE FOR SUCCEEDING LEVELS OF DECOMPOSITION.

DECOMPOSITION OF SOLUTION: TRACKING PROGRAM

OBJECTS

TEST POINTS

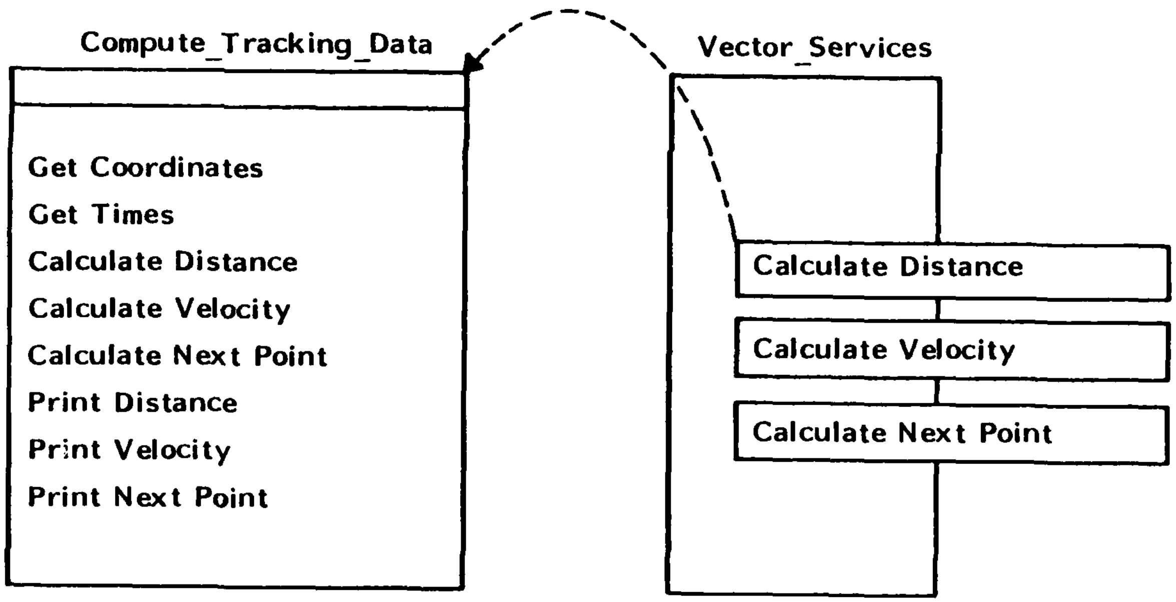
TEST TIMES

OPERATIONS

CALCULATE DISTANCE

CALCULATE VELOCITY

CALCULATE NEXT POINT



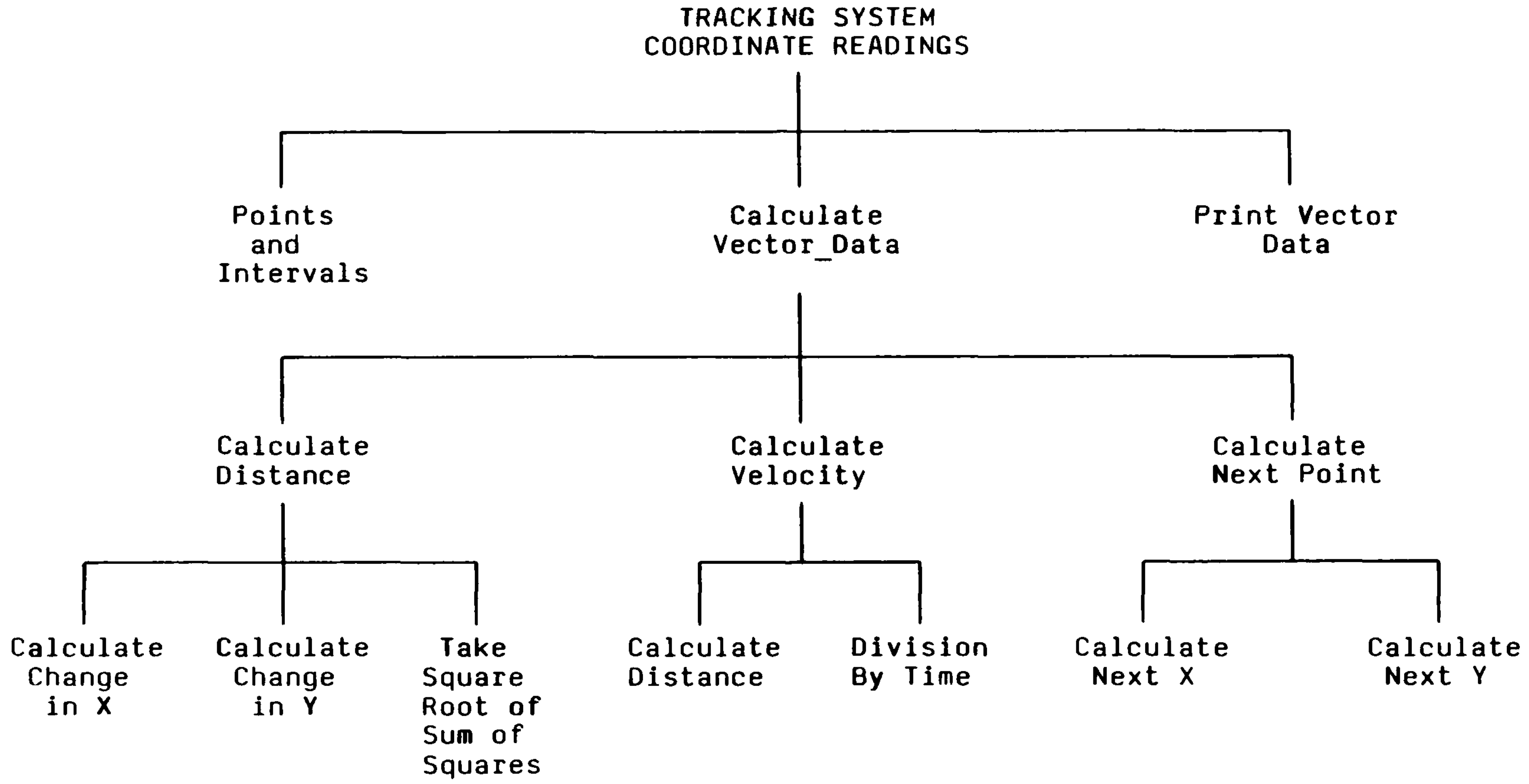
INSTRUCTOR NOTES

THE DIAGRAM SUMMARIZES THE LEVELS OF DECOMPOSITION OF THE SAMPLE DESIGN.

WE NOW TURN TO THE ACTUAL ADA CODING PHASE.

THE NAMES IN THE DIAGRAM ARE NOT THE NAMES OF THE RESULTING SUBPROGRAMS. HERE WE ARE DISCUSSING FUNCTIONS (NOT THE ADA TYPE).

DESIGN SOLUTION SUMMARY



TRACKING SYSTEM COORDINATE READINGS

Points and Intervals

Calculate Vector_Data

Print Vector Data

Calculate Distance

Calculate Velocity

Calculate Next Point

Calculate Change in X

Calculate Change in Y

Take Square Root of Sum of Squares

Calculate Distance

Division By Time

Calculate Next X

Calculate Next Y

INSTRUCTOR NOTES

THE LISTED ADA FEATURES WILL BE DISCUSSED AS PREPARATION IS MADE FOR THE CODING OF THE SOLUTION.

THESE STUDENTS WILL BE FAMILIAR WITH THE ALGORITHMS, SO DO NOT SPEND A LOT OF TIME DISCUSSING THE ALGORITHMS IN THE FOLLOWING SLIDES.

AS WE EXPRESS OUR SOLUTION FOR A TRACKING PROGRAM IN ADA, WE MUST LOOK AT:

- PACKAGES
- SUBPROGRAMS
- CONTROL STRUCTURES AND STATEMENTS
- TYPES AND DECLARATIONS

INSTRUCTOR NOTES

A LOOK AT THE RESOURCES NEEDED BY THE MAIN PROCEDURE REVEALS THAT THEY ALL PROVIDE VECTOR CALCULATION SERVICES OF SOME NATURE. THEY COULD EVEN BE USED BY SOME OTHER TRACKING SYSTEM. SO LET'S GROUP THESE RESOURCES TOGETHER IN SUCH A WAY THAT OTHER SYSTEMS CAN USE THEM. THIS IS DONE THROUGH THE ADA PROGRAM UNIT CALLED PACKAGES.

PACKAGES HAVE TWO PARTS. THE FIRST IS CALLED THE SPECIFICATION. IT TELLS WHAT KINDS OF ACTIONS OR DATA CAN BE USED.

POINT OUT THE TYPE DEFINITIONS. A DESIGN DECISION TO REPRESENT EACH POINT AS AN ARRAY WAS MADE. ARRAYS IN ADA ARE SIMILAR TO ARRAYS IN OTHER LANGUAGES; THEY WILL HAVE A SPECIFIC FORM OR TEMPLATE WHICH IS DESCRIBED IN AN ARRAY TYPE DEFINITION. THE TYPE DEFINITION PROVIDES A DESCRIPTION OF WHAT AN OBJECT OF THE TYPE WOULD LOOK LIKE-IT DOES NOT ALLOCATE ANY STORAGE.

THIS PACKAGE, CALLED Vector_Services, SHOWS HOW ALL OF OUR TRACKING RESOURCES CAN BE COLLECTED IN ONE LOGICAL UNIT, FOR USE BY THE MAIN PROGRAM. THE SPECIFICATION PROVIDES ALL INFORMATION NECESSARY TO USE THESE RESOURCES; WE DON'T NEED TO KNOW HOW THEY ARE IMPLEMENTED TO BE ABLE TO CODE THE MAIN PROGRAM.

PACKAGES

TYPE DECLARATIONS

SPECIFICATION

```
package Vector_Services is
    type Coordinate_Type is (X,Y);

    type Point_Type is array (Coordinate_Type) of Float;

    subtype Time_Type is Duration;

    function Distance_Between (Last_Point,
                               This_Point : Point_Type) return Float;

    procedure Calculate_Velocity (From, To : in Point_Type;
                                  In_Time  : in Time_Type;
                                  Velocity : out Float);

    function Next_Point_After (Last_Point, This_Point : in Point Type;
                               Time_Between_Last,
                               Time_Between_Next : Time_Type)

                    return Point_Type;
end Vector_Services;
```

INSTRUCTOR NOTES

THE ADA SYSTEM CAN NOW BE FURTHER DEVELOPED BY CODING THE MAIN LOGIC PROCEDURE. THE TRACKING RESOURCES ARE PROVIDED BY THE Vector_Services PACKAGE JUST SHOWN. THE 'WITH' STATEMENT MUST BE USED TO "HOOK TOGETHER" THE MAIN PROGRAM AND THE PACKAGE. THE RESOURCES FROM AN I/O PACKAGE CALLED Text_IO WILL ALSO BE USED.

PROCEDURE Compute_Tracking_Data HAS THE SAME FORMAT AS ANY OTHER PROCEDURE (EXCEPT IT HAS NO PARAMETERS). THIS SLIDE SHOWS THE DECLARATION FOR ALL DATA OBJECTS AND LOCAL ROUTINES TO BE USED IN THE STATEMENT PART. THE USE OF "IS SEPARATE" WILL BE DISCUSSED IN LATER SLIDES.

POINT OUT THE OBJECT DECLARATIONS CREATING OBJECTS OF TYPES Point_Type AND Time_Type (SHOWN ON THE PREVIOUS SLIDE) AS WELL AS OBJECTS OF THE PREDEFINED TYPE FLOAT. EACH OBJECT IS GIVEN A NAME THAT REPRESENTS ITS INTENDED FUNCTION. THE TYPE TEMPLATE NAME DETERMINES NOW THE OBJECT WILL "LOOK" AND FUNCTION. (DON'T GO INTO DETAIL OR SYNTAX.)

(IF POSSIBLE, DISPLAY THIS SLIDE AND THE NEXT AT THE SAME TIME.)

MAIN PROGRAM LOGIC

DECLARATIONS:

OBJECT DECLARATIONS

```
with Text_IO, Vector_Services;
use Vector_Services;
procedure Compute_Tracking_Data is

   Last_Point, Current_Point, Next_Point : Point_Type;
   Time_Elapsed, Time_Projected : Time_Type;
   Distance, Velocity : Float;

   package Time_IO is new Text_IO.Fixed_IO (Time_Type);
   package Flt_IO  is new Text_IO.Float_IO (Float);

   procedure Get_Point (P : out Point_Type) is separate;
   procedure Put_Point (P : in  Point_Type) is separate;

begin
```

EXECUTABLE STATEMENTS ON NEXT PAGE

```
end Compute_Tracking_Data;
```

INSTRUCTOR NOTES

THIS SLIDE SHOWS THE STATEMENT PART OF Compute_Tracking_Data.

STATEMENTS TO READ IN THE POINTS AND TIMES WITH THE SERVICES OF Text_IO; THE DESIRED INFORMATION IS CALCULATED VIA PROCEDURE AND FUNCTION CALLS; AND WE PRINT OUT RESULTS WITH THE SERVICES OF Simple_IO. NOTICE THE SUBSTITUTION OF ACTUAL PARAMETERS FOR THE FORMAL PARAMETERS OF THE SUBPROGRAM DEFINITIONS.

IF ASKED, Calculate_Velocity IS A PROCEDURE RATHER THAN A FUNCTION FOR THE PURPOSE OF COMPARING PROCEDURES AND FUNCTIONS.

MAIN PROGRAM LOGIC (CONT.)

STATEMENTS:

```
with Text_IO, Vector_Services;
use Vector_Services;
procedure Compute_Tracking_Data is

                    DECLARATIONS ON PREVIOUS PAGE

begin -- Compute_Tracking_Data
    Text_IO.Put ("Enter coordinates of last position: ");
    Get_Point (Last_Point);
    Text_IO.Put ("Enter coordinates of current position: ");
    Get_Point (Current_Point);

    Text_IO.Put ("Time (in seconds) between readings : ");
    Time_IO.Get (Time_Elapsed); Text_IO.New_Line;
    Text_IO.Put ("Time (in seconds) until next reading : ");
    Time_IO.Get (Time_Projected); Text_IO.New_Line;

    Distance := Distance_Between (Last_Point, Current_Point);
    Calculate_Velocity (Last_Point, Current_Point, Time_Elapsed, Velocity);
    Next_Point := Next_Point_After (Last_Point, Current_Point,
                                    Time_Elapsed, Time_Projected);

    Text_IO.Put ("Distance between points was")
    Flt_IO.Put  (Distance);
    Text_IO.Put-Line ("units.");

    Text_IO.Put ("Velocity was");
    Flt_IO.Put  (Velocity);
    Text_IO.Put ("units per second.");

    Text_IO.Put ("After");
    Time_IO.Put (Time_Projected);
    Text_IO.Put ("seconds, the next point sould be");
    Put_Point (Next_Point);

end Compute_Tracking_Data;
```

INSTRUCTOR NOTES

THEN IN THE SECOND PART OF THE PROGRAM UNIT, THE BODY, IS THE ACTUAL CODE THAT PERFORMS THE RESOURCES ACTIONS. THIS SLIDE SHOWS THE FIRST TWO SUBPROGRAM BODIES -- THE OTHER TWO ARE ON THE FOLLOWING SLIDE.

NOTICE THAT PROCEDURE SQRT WAS NOT LISTED IN THE SPECIFICATION. SQRT IS A UTILITY WHICH WILL ONLY BE USED BY THE ALGORITHM Distance_Between. BY PLACING IT IN THE PACKAGE BODY, WE ENSURE THAT NO UNAUTHORIZED TAMPERING OF THE DATA CAN BE DONE.

BRIEFLY DISCUSS THE INDICATED CONTROL STRUCTURES, POINTING OUT RESERVED WORDS (UNDERLINING MAY BE HELPFUL). DO NOT GET BOGGED DOWN IN SYNTAX; FOCUS ON GENERAL STRUCTURE AND FUNCTION. POINT OUT NESTED CONTROL STRUCTURE, WITH INDENTATION SHOWING LOGICAL NESTING.

THE while LOOP IS AN ITERATIVE CONTROL STRUCTURE, ALLOWING REPETITION OF SOME SEQUENCE OF ACTION WHILE SOME CONDITION IS PRESENT. THE OTHER ITERATIVE CONTROL STRUCTURE IS THE for LOOP (NOT SHOWN), WHICH ALLOWS REPETITION FOR A SPECIFIED NUMBER OF TIMES.

THE VECTOR PACKAGE BODY

```
package body Vector_Services is

   function Sqrt (X : Float) return Float is
      Epsilon : constant := 0.000001;                       -- LOCAL DECLARATIONS
      Root : Float := 1.0;
   begin
      if X = 0.0 then                                      IF/THEN/ELSE CONTROL STRUCTURE
         return 0.0;
      else
         Root := (X/Root + Root) / 2.0;
         while abs (X/Root**2 - 1.0) >= Epsilon            LOOP CONTROL STRUCTURE
            loop
               Root := (X/Root + Root) / 2.0;
            end loop;
         return Root;
      end if;
   end Sqrt;

   function Distance_Between (Last_Point, This Point : Point_Type) return Float is
      Dx, Dy : Float;
   begin
      Dx := abs (This_Point(X) - Last_Point(X));
      Dy := abs (This_Point(Y) - Last_Point(Y));
      return ( Sqrt( Dx**2 + Dy**2) );
   end Distance_Between;
```

INSTRUCTOR NOTES

DATA DECLARATIONS, CONTROL STRUCTURES, AND ASSIGNMENT STATEMENTS ARE BUILT INTO FUNCTIONAL (EXECUTABLE) STRUCTURES KNOWN AS SUBPROGRAMS IN ADA. SUBPROGRAMS HAVE 2 FORMS - PROCEDURES AND FUNCTIONS, SIMILAR TO OTHER LANGUAGES.

INDICATE PROCEDURE AND FUNCTION TEMPLATE STRUCTURE BY UNERLINING RESERVED WORDS.

A PROCEDURE BEGINS EXECUTION THROUGH A PROCEDURE CALL (SHOWN IN MAIN PROCEDURE BODY), WHICH IS A STATEMENT. A FUNCTION CALL IS AN EXPRESSION (RETURNS A VALUE); THUS EVERY FUNCTION MUST SPECIFY A RETURN TYPE AND MUST EXPLICITLY RETURN A VALUE VIA A RETURN STATEMENT.

POINT OUT THE PARAMETER LISTS AND MODE INDICATIONS. A PARAMETER OF MODE IN IS PASSED TO THE SUBPROGRAM BUT CANNOT BE MODIFIED IN IT; AN OUT PARAMETER IS ONE THAT RETURNS A VALUE ASSIGNED TO IT IN THE SUBPROGRAM. A THIRD MODE, IN OUT, INDICATES A PARAMETER THAT IS PASSED IN, MODIFIED, AND PASSED OUT AGAIN. A FUNCTION PARAMETER MAY BE OF MODE IN ONLY.

PACKAGE BODY (CONT.)

```
   procedure Calculate_Velocity (From, To : in Point_Type);  -- FORMAL DEFINITION OF
                                 In_Time  : in Time_Type;    -- Calcualte_Velocity with
                                 Velocity : out Float)   is  -- FORMAL (DUMMY) PARAMETER LIST

   begin
         Velocity := Distance_Between(From, To)/Float(In_Time);
   end Calculate_Velocity;


   function Next_Point_After (Last_Point, This_Point : in Point_Type;
                              Time_Between_Last, Time_Between_Next : Time_Type)
               return Point_Type is                        -- VALUE RETURNED IS OF Point_Type
        Next_Point : Point_Type;

   begin

      if Time_Between_Last = 0 then
         return This_Point;
      else
         Next_Point(X) := Last_Point(X) + Float(Time_Between_Next/Time_Between_Last)
                             * abs (This_Point(X) - Last_Point(X));
         Next_Point(Y) := Last_Point(Y) + Float(Time_Between_Next/Time_Between_Last)
                             * abs (This_Point(Y) - Last_Point(Y));
         return Next_Point;                                 -- MANDATORY EXPLICIT RETURN
      end if;

   end Next_Point_After;


end Vector_Services;
```

INSTRUCTOR NOTES

CODING OF THE ADA SYSTEM IS COMPLETED. NEXT THE TOPIC OF COMPILATION IN ADA IS DISCUSSED.

EXPECT SOME QUESTION ABOUT CURRENT IMPLEMENTATIONS OF ADA, SUCH AS SPEED OF EXECUTION, SPEED OF COMPILATION, ETC. TELL THE STUDENTS (IF YOU DO NOT KNOW THESE FIGURES) THAT ADA COMPILERS ARE TOO NEW TO ADEQUATELY ANSWER THESE QUESTIONS.

BREAK HERE FOR 15 MINUTES.

WE NOW NEED TO COMPILE OUR ADA SYSTEM

INSTRUCTOR NOTES

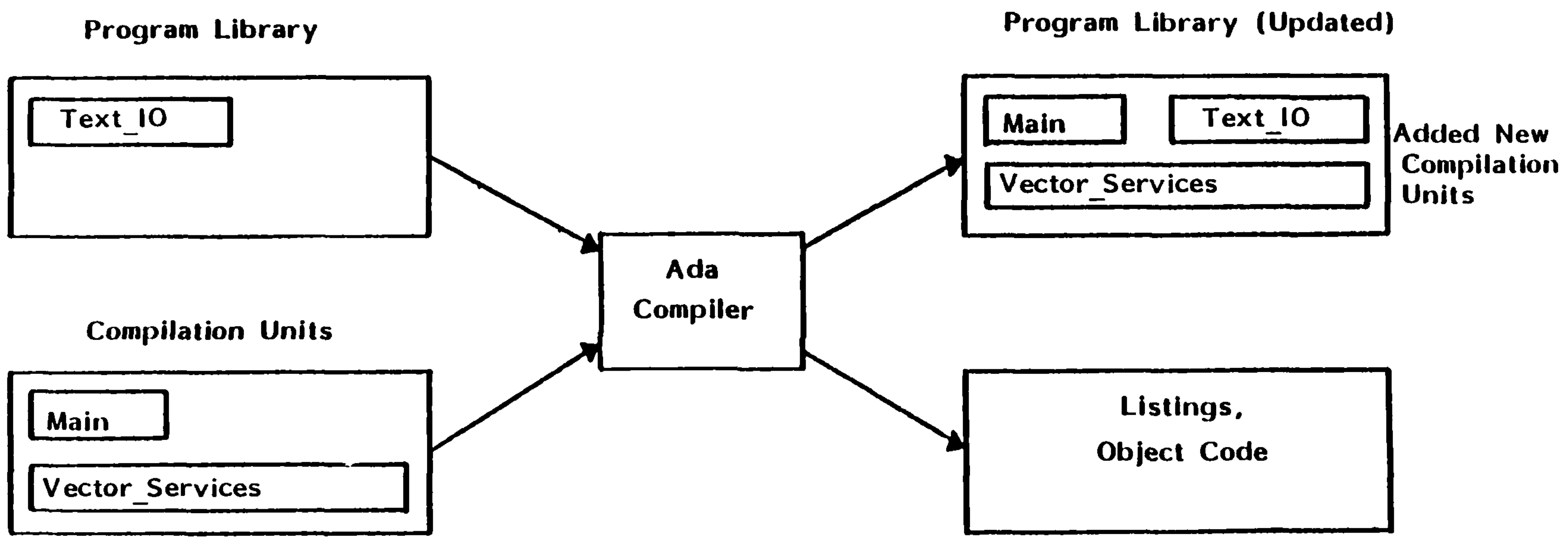
COMPILATION UNITS ARE PARTS OF ADA CODE THAT THE LANGUAGE SAYS CAN BE SUBMITTED BY THEMSELVES TO AN ADA COMPILER.

COMPILATION CONSISTS OF SUBMITTING OUR COMPILATION UNITS PLUS THE PROGRAM LIBRARY WHICH IS A FILE THAT WILL CONTAIN CERTAIN INFORMATION ABOUT A UNIT THAT SUBSEQUENT COMPILER SUBMISSION WILL NEED. ONCE COMPILED, THE SUBMITTED COMPILATION UNITS ARE ADDED TO THE PROGRAM LIBRARY.

MAIN = Compute_Tracking_Data ON FOLLOWING CHARTS
(DUE TO SPACE LIMITATIONS).

COMPILATION OF OUR TRACKING SYSTEM

- SUBMIT ALL PROGRAM PARTS AT ONE TIME:



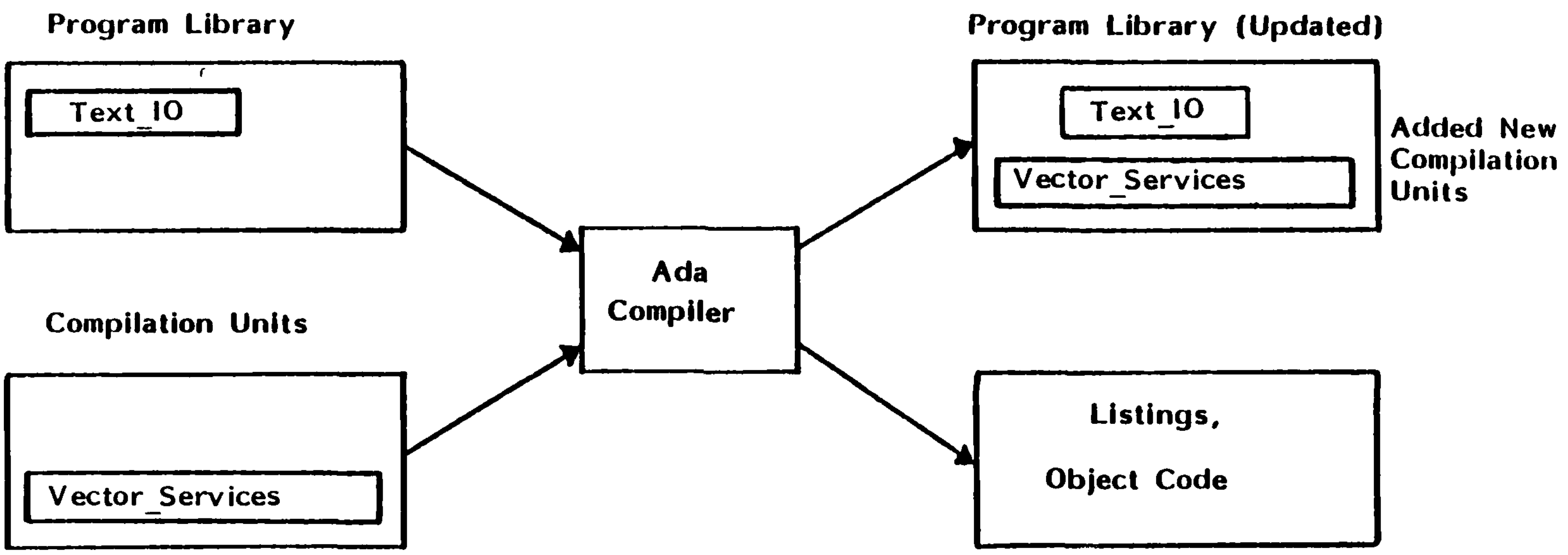
INSTRUCTOR NOTES

INSTEAD OF SUBMITTING ALL OUR PROGRAM PARTS AT ONE TIME, WE COULD SUBMIT THEM SEPARATELY. LET'S SAY PROGRAMMER 1 CODED OUR Vector_Services PACKAGE. INSTEAD OF WAITING FOR PROGRAMMER 2, WHO WILL HAVE HER CODE COMPLETED LATER, WE CAN COMPILE THE Vector_Services PACKAGE. THE COMPILER WILL ADD THE NECESSARY INFORMATION ABOUT THE PACKAGE TO THE PROGRAM LIBRARY.

ALTERNATE COMPILATION OF OUR HOBBIT SYSTEM

- SUBMIT PROGRAM PARTS (COMPILATION UNITS) SEPARATELY:

RUN 1



Program Library

Text_IO

Compilation Units

Vector_Services

Ada Compiler

Program Library (Updated)

Text_IO

Vector_Services

Added New Compilation Units

Listings,

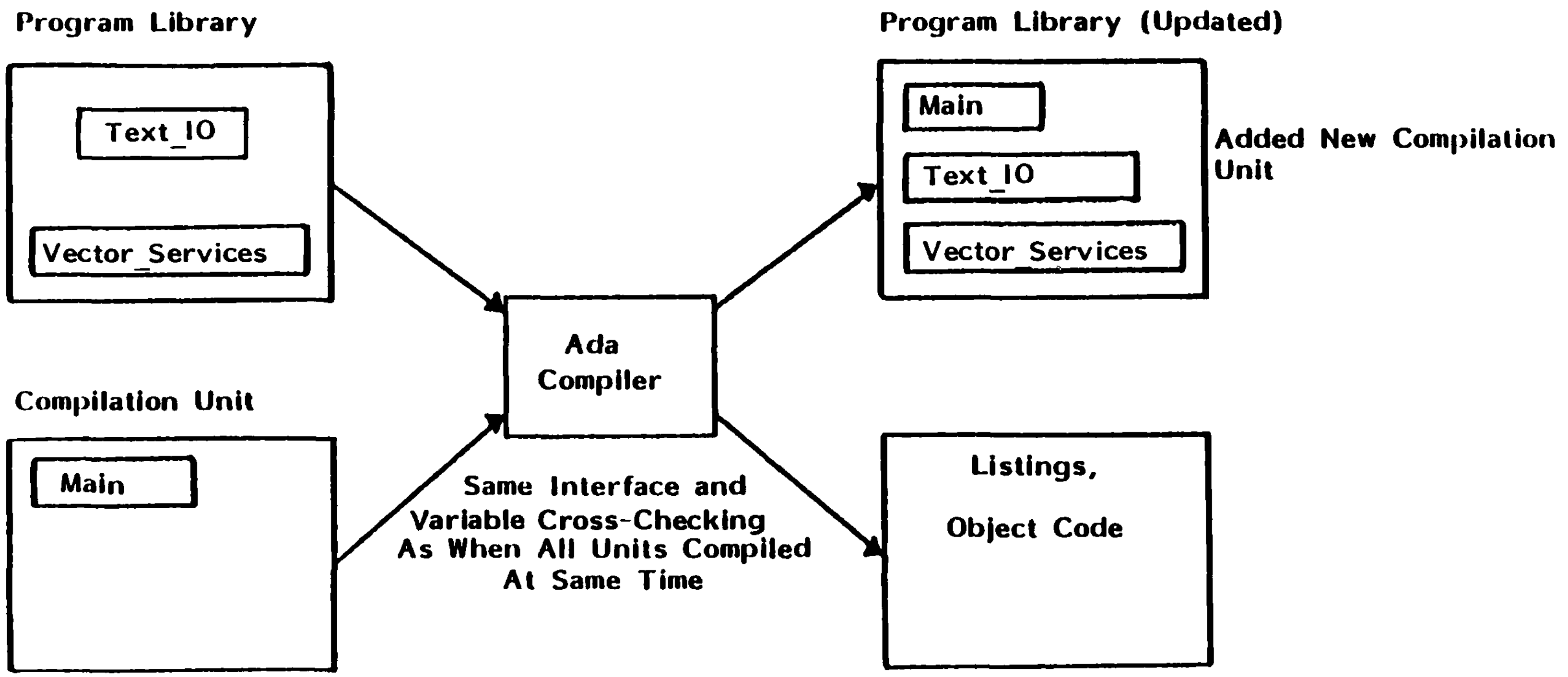
Object Code

INSTRUCTOR NOTES

WHEN PROGRAMMER 2 IS FINISHED, WE THEN SUBMIT OUR PROCEDURE MAIN PLUS THE PROGRAM LIBRARY TO THE ADA COMPILER. WITH THE INFORMATION CONTAINED IN THE PROGRAM LIBRARY, THE COMPILER CAN DO THE SAME INTERFACE AND VARIABLE CROSS-CHECKING BETWEEN MAIN AND THE PACKAGE - JUST AS IF THEY HAD BEEN COMPILED AT THE SAME TIME. THIS THEN IS AN EXAMPLE OF SEPARATE COMPILATION.

ALTERNATE COMPILATION (Continued)

RUN 2


Program Library
Text_IO
Vector_Services
Compilation Unit
Main
Ada Compiler
Same Interface and Variable Cross-Checking As When All Units Compiled At Same Time
Program Library (Updated)
Main
Text_IO
Vector Services
Added New Compilation Unit
Listings,
Object Code

THIS WAY IS CALLED SEPARATE COMPILATION.

INSTRUCTOR NOTES

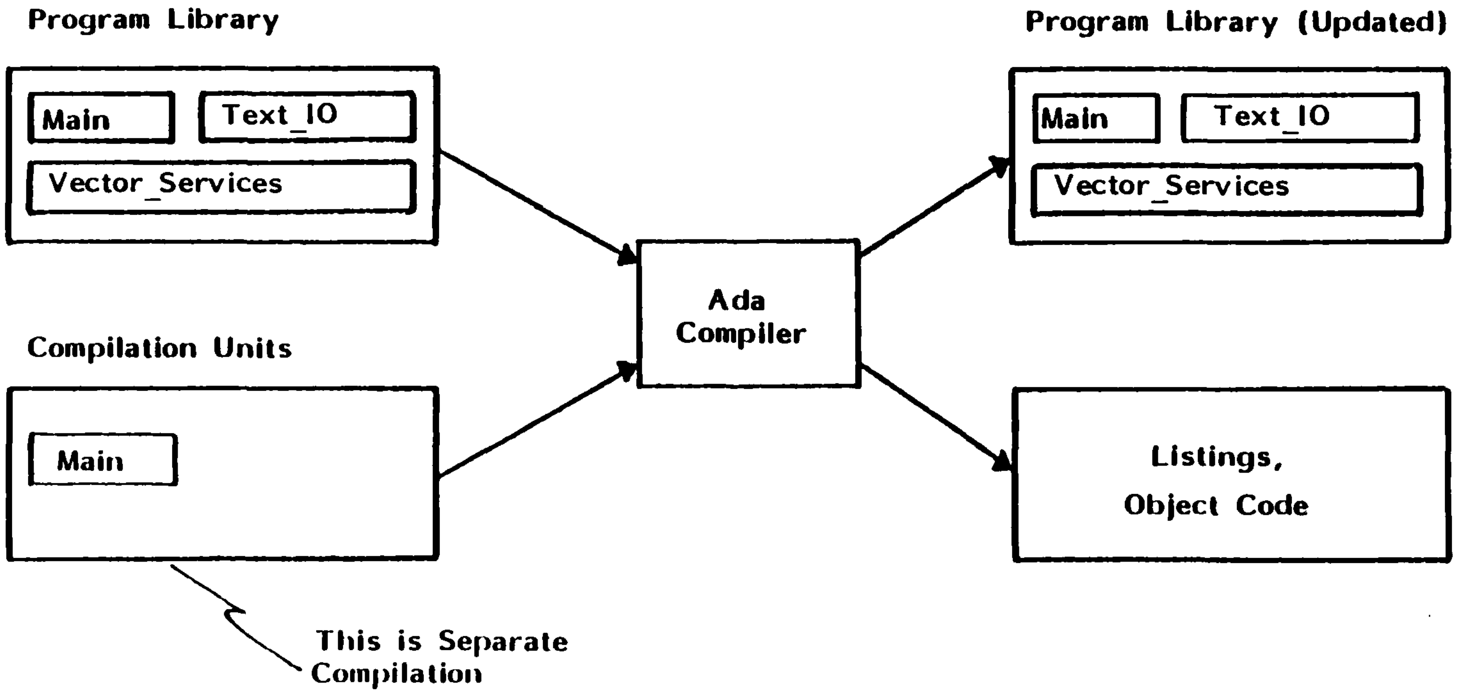
THE NATURE OF LARGE SYSTEMS IS CONTINUAL CHANGE. WE NEXT LOOK AT HOW THAT CAN AFFECT OUR SOLUTION.

THE GOAL OF THIS SLIDE IS TO ILLUSTRATE ONE OF THE GREAT ADVANTAGES OF ADA - THE PACKAGE - FOR LOCALIZATION OF EFFECT OF CHANGES.

ASK THE CLASS: IF WE WANT TO CHANGE THE OUTPUT FORMATS, WHAT DO WE NEED TO CHANGE?

CHANGES TO THE SYSTEM: MAIN PROCEDURE

WE NEED TO CHANGE ONE OF THE PRINTOUT FORMATS. SINCE THE PACKAGE WORRIES ABOUT ALL AND ONLY THE VECTOR CALCULATIONS, THE PACKAGE NEED NOT BE CHANGED OR RECOMPILED.



Program Library

Main

Text_IO

Vector_Services

Compilation Units

Main

Ada Compiler

Program Library (Updated)

Main

Text_IO

Vector_Services

Listings, Object Code

This is Separate Compilation

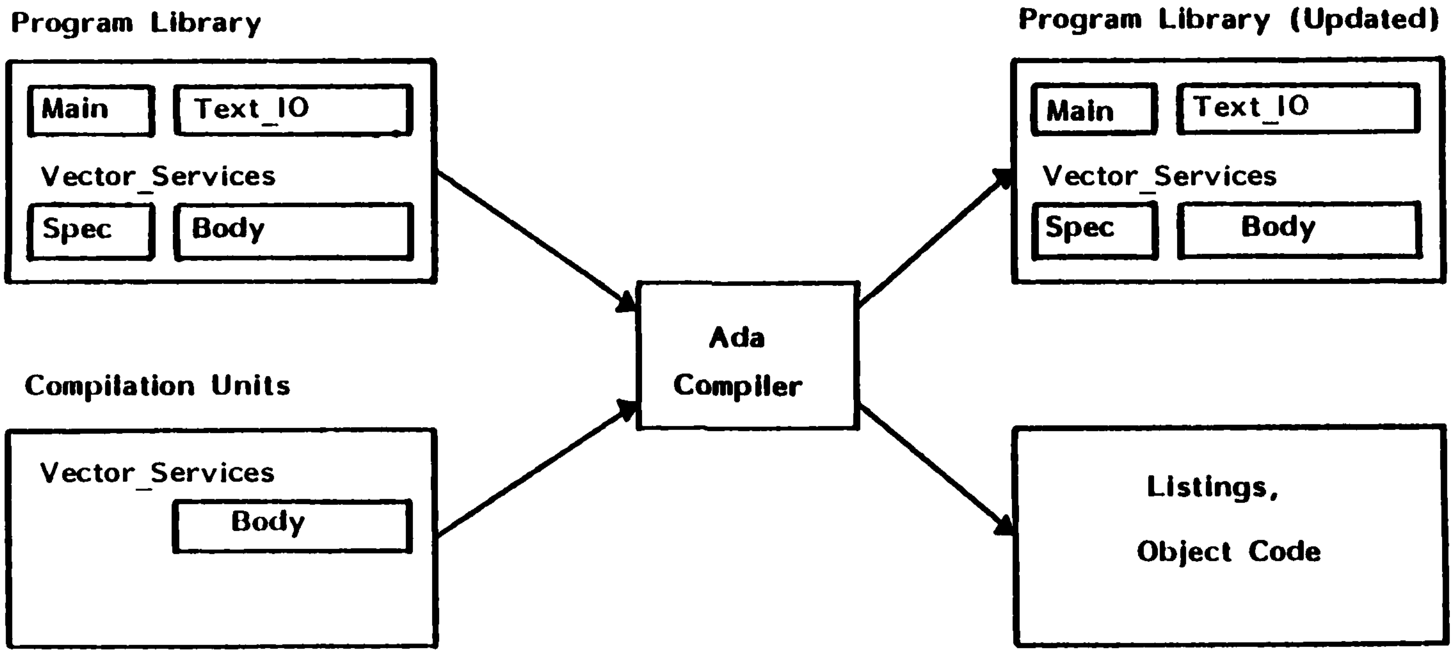
INSTRUCTOR NOTES

ANOTHER EXAMPLE OF EASE OF CHANGE.

POINT OUT THAT NEITHER PROCEDURE MAIN NOR THE PACKAGE SPECIFICATION FOR Vector_Services NEED TO BE RECOMPILED.

CHANGES TO THE SYSTEM: PACKAGE BODY

WE FIND A BETTER ALGORITHM FOR ONE OF OUR Vector ROUTINES. SINCE WE COLLECTED OUR ROUTINES IN A PACKAGE, WE CAN MAKE THE CHANGE TO THE PACKAGE BODY Vector_Service WITHOUT REQUIRING ANY CHANGES TO THE MAIN PROCEDURE OR THE PACKAGE SPECIFICATION FOR Vector_Services.

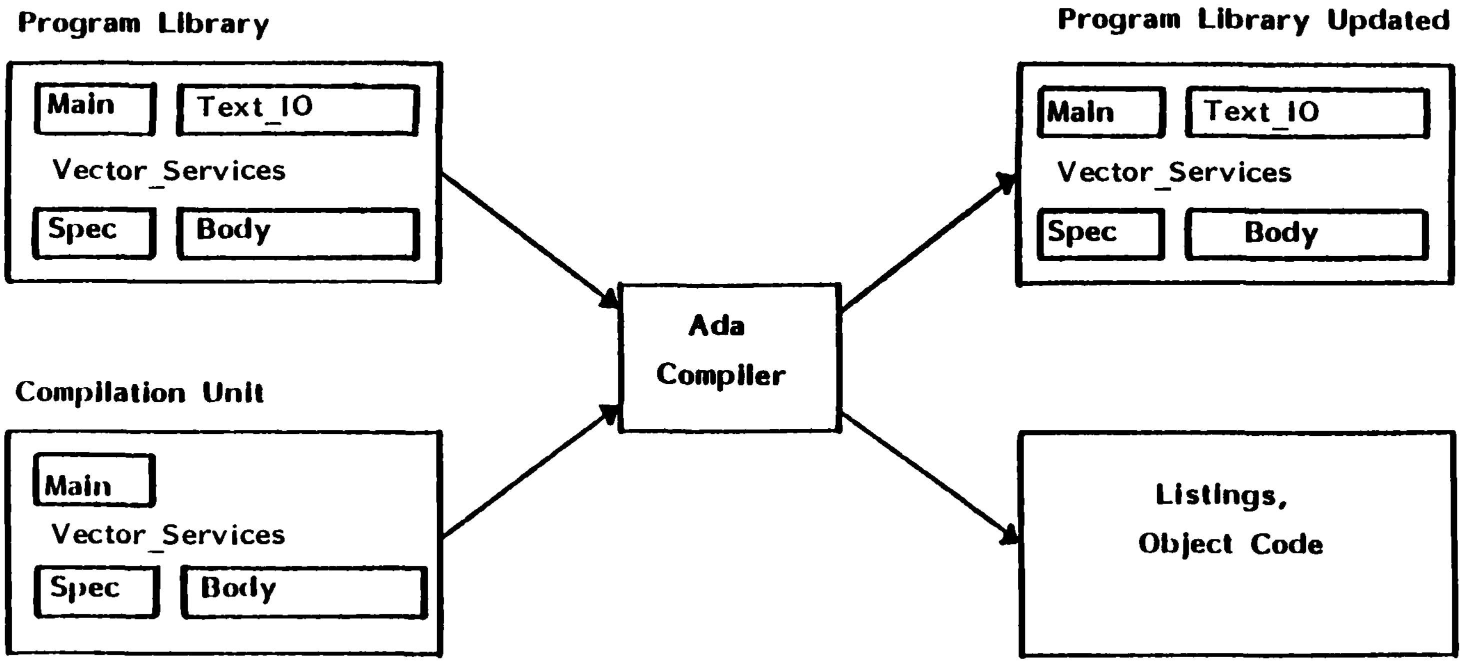


Separate Compilation

CHANGES TO THE SYSTEM: ADDING A ROUTINE

WE WANT TO ADD A ROUTINE TO COMPUTE THE ANGLE OF THE Vector SINCE WE COLLECTED OUR Vector ROUTINES IN A PACKAGE, WE WANT TO ADD THIS ROUTINE TO THE PACKAGES SPECIFICATION AND BODY OF Vector_Services. WE MODIFIED Vector_Services AND OUR MAIN PROCEDURE DEPENDS ON THOSE RESOURCES.

AS A RESULT WE MUST ALSO RECOMPILE THE MAIN PROCEDURE.



INSTRUCTOR NOTES

THE NEXT SEVERAL SLIDES SET UP THE MOTIVATION AND ILLUSTRATE THE USE OF SUBUNITS.

WE'D LIKE TO KEEP OUR SYSTEM UNDERSTANDABLE AND READABLE. IN PURSUING THIS GOAL, WE RETURN TO THE PACKAGE BODY OF Vector_Services.

INSTRUCTOR NOTES

IN REALITY THE '...' IS A NUMBER OF LINES OF CODE. AS SHOWN ON TWO PREVIOUS SLIDES IN THIS FORM, WE REALLY CAN'T SEE THE STRUCTURE OF THE BODY OR EASILY FIND A SECTION OF CODE WE MAY BE INTERESTED IN.

PACKAGE BODY STRUCTURE

- THIS FORMAT CAN BE CONFUSING IN REALITY

```
package body Vector_Services is
   function Sqrt (X : Float) return Float is
      Epsilon: constant := 0.000001;
      Root: Float := 1.0;
   begin
      if X = 0.0 then
         return 0.0;
      else
         Root := (X/Root + Root)/2.0;
         while abs (X/Root **2 - 1.0) > = Epsilon
            loop
               Root := (X/Root + Root)/2.0;
            end loop;
         return Root;
      end if;
   end Sqrt;
   function Distance_Between (Last_Point, This_Point : Point_Type)
                        return Float is ... begin ... end;
   procedure Calculate_Velocity (From, To : in Point_Type;
                                 In_Time  : in Time_Type;
                                 Velocity : out Float) is ... begin ... end;
   function Next_Point_After (Last_Point, This_Point : in Point_Type;
                           Time_Between_Last, Time_Between_Next : Time_Type)
                        return Point_Type is ... begin ... end;
end Vector_Services;
```

INSTRUCTOR NOTES

ADA ALLOWS US TO CAPTURE THE INITIAL STRUCTURE AND COMPOSITION OF THE PACKAGE BODY THROUGH STUBBING.

'IS SEPARATE' JUST SAYS TO THE COMPILER, "YOU WILL FIND THE ACTUAL CODE FOR THIS SUBPROGRAM IN A SEPARATE PLACE FROM THE PARENT (OR CONTAINING) ADA UNIT".

IN CONCEPT, STUBBING IS SIMILAR TO SUBROUTINES IN FORTRAN, ASSEMBLY LANGUAGE, JOVIAL.

ALTERNATIVE PACKAGE BODY STRUCTURE

```
package body Vector_Services is
   function Sqrt (X : Float) return Float is separate; -- A STUB
   function Distance_Between (Last_Point, This_Point : Point_Type)
                        return Float is separate;
   procedure Calculate_Velocity (From, To : in Point_Type;
                                 In_Time  : in Time_Type;
                                 Velocity : out Float) is separate;
   function Next_Point_After (Last_Point, This_Point : in Point_Type;
                              Time_Between_Last, Time_Between_Next : Time_Type)
                        return Point_Type is separate;
end Vector_Services;
```

INSTRUCTOR NOTES

- IN ADDITION, FOR EACH 'SEPARATE' SUBPROGRAM (SUBUNIT) WE INDICATE THE PARENT UNIT

```
separate (Vector_Services)     -- We Add This Line
function Next_Point_After (Last_Point, This_Point : in Point_Type;
                          Time_Between_Last, Time_Between_Next : Time_Type)
                          return Point_Type is

     Next_Point : Point_Type;

begin

   if Time_Between_Last = 0 then
      return This_Point;
   else
      Next_Point(X) := Last_Point(X) + Float(Time_Between_Next/Time_Between_Last)
                          * abs (This_Point(X) - Last_Point(X));
      Next_Point(Y) := Last_Point(Y) + Float(Time_Between_Next/Time_Between_Last)
                          * abs (This_Point(Y) - Last_Point(Y));
      return Next_Point;
   end if;

end Next_Point_After;
```

INSTRUCTOR NOTES

THESE ARE THE SUBUNITS STUBBED OUT OF THE MAIN PROCEDURE. NOTE THAT THIS CODE WOULD ADD CONSIDERABLE BULK TO THE MAIN PROCEDURE BODY IF USED INLINE, WHILE CONTRIBUTING LITTLE TO THE LOGICAL STRUCTURE. STUBBING OUT THESE ROUTINES ALLOWS EASY MODIFICATION OF I/O FORMAT.

MORE SUBUNITS

```
separate (Compute_Tracking_Data)
procedure Get_Point (P : out Point_Type) is
begin
   Text_IO.Put ("  X = ");
   Flt_IO.Get (P(X));
   Text_IO.Put (";  Y = ");
   Flt_IO.Get (P(Y));
   Text_IO.New_Line;
end;

separate (Compute_Tracking_Data)
procedure Put_Point (P : in Point_Type) is
begin
   Text_IO.Put ("(");
   Flt_IO.Put (P(X));
   Text_IO.Put (",");
   Flt_IO.Put (P(Y));
   Text_IO.Put (")");
end;
```

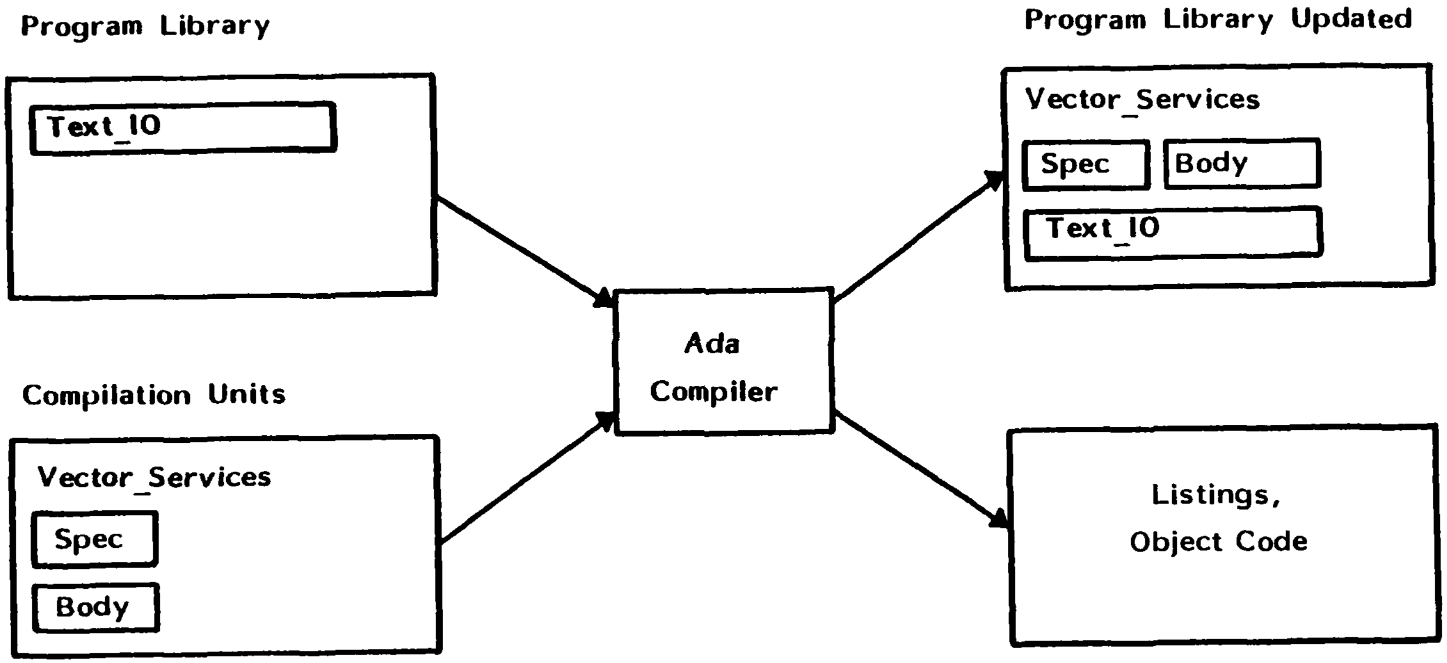
INSTRUCTOR NOTES

THE FOLLOWING EXAMPLE SPANS 3 SLIDES AND STEPS THROUGH ONE POSSIBLE WAY TO SEPARATELY COMPILE THE SYSTEM WE'VE JUST SEGMENTED.

SPECS MUST BE COMPILED BEFORE BODIES.

TO SEPARATELY COMPILE OUR SYSTEM WITH SUBUNITS, AN EXAMPLE:

RUN 1



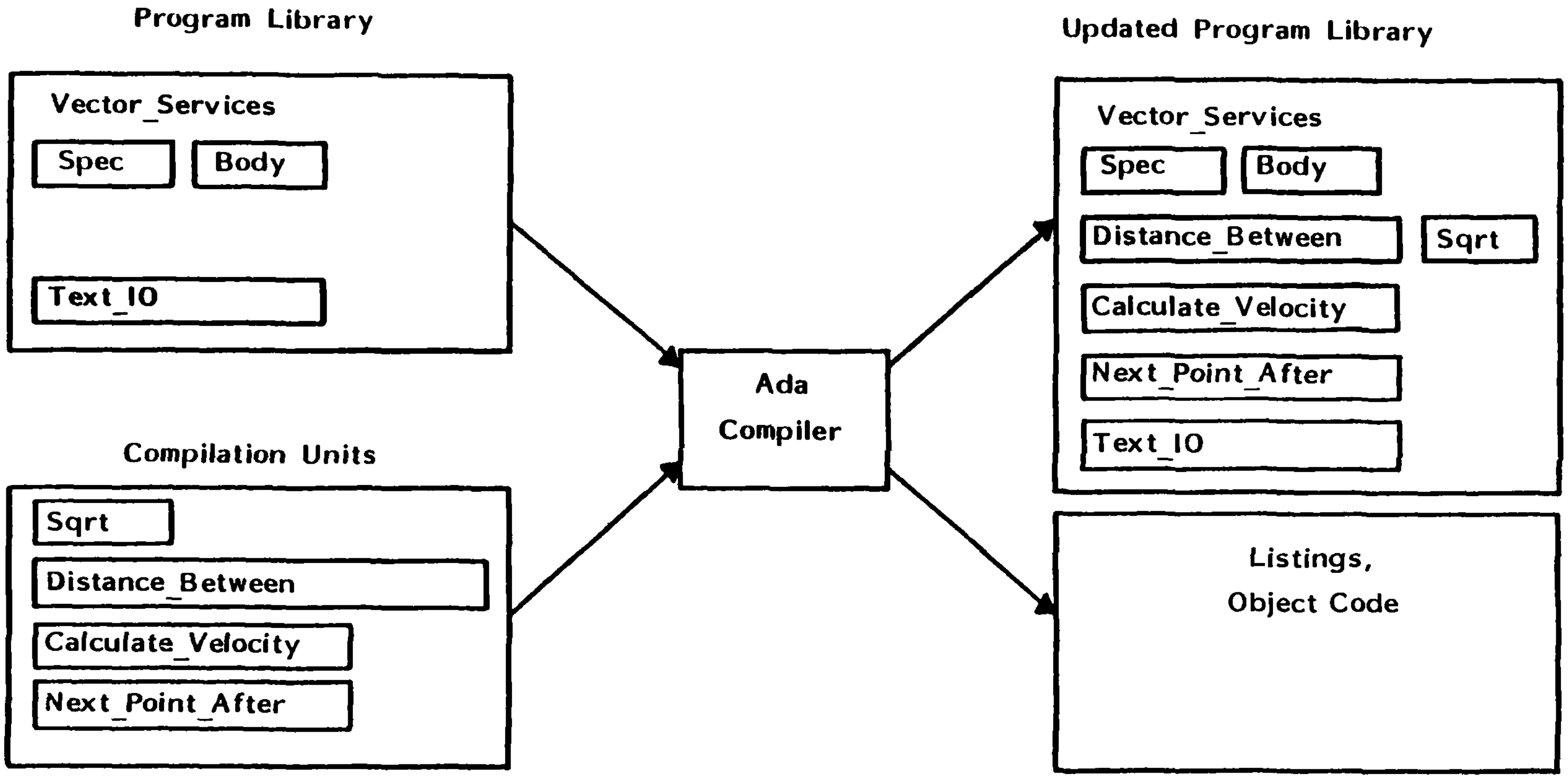
VG 732.1

INSTRUCTOR NOTES

FOR OUR EXAMPLE, WE WILL COMPILE THE PACKAGE SUBUNITS AND ADD THEM TO THE PROGRAM LIBRARY.

ALL FOUR SUBUNITS NEED NOT BE COMPILED AT THE SAME TIME. HOWEVER, ANY SUBUNIT THAT DEPENDS ON ANOTHER MUST BE COMPILED AFTER THE ONE UPON WHICH IT DEPENDS. FOR EXAMPLE, Distance_Between MUST BE COMPILED BEFORE Calculate_Velocity.

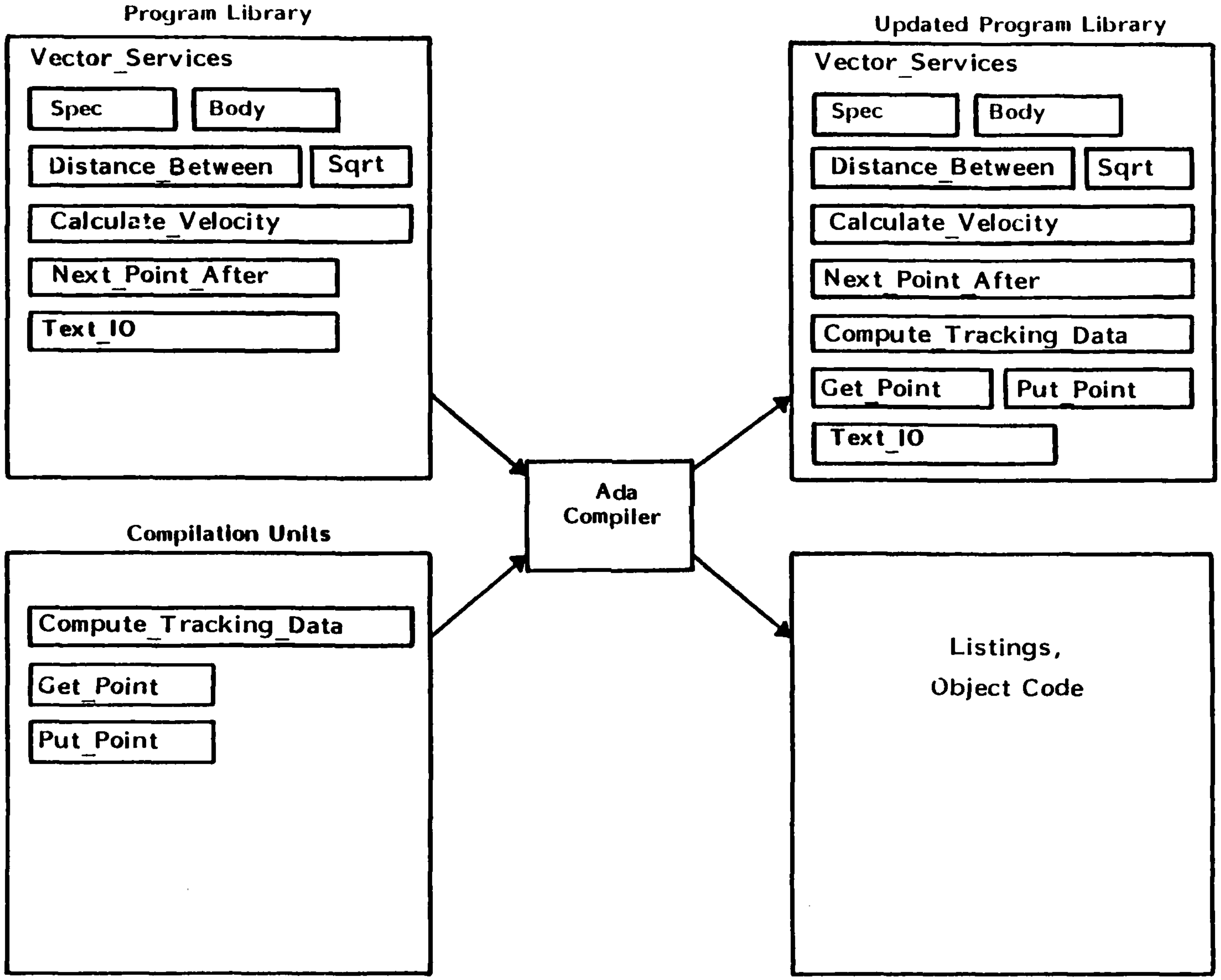
RUN 2


Program Library
Vector_Services
Spec
Body
Text_IO
Compilation Units
Sqrt
Distance_Between
Calculate_Velocity
Next_Point_After
Ada
Compiler
Updated Program Library
Vector_Services
Spec
Body
Distance_Between
Sqrt
Calculate_Velocity
Next_Point_After
Text_IO
Listings,
Object Code

INSTRUCTOR NOTES

ONCE ALL THE RESOURCE PIECES NEEDED BY THE MAIN PROCEDURE ARE IN PROGRAM LIBRARY, WE CAN COMPILE Compute_Tracking_Data AND ITS SUBUNITS.

RUN 3



Program Library

Vector_Services

Spec

Body

Distance_Between

Sqrt

Calculate_Velocity

Next_Point_After

Text_IO

Compilation Units

Compute_Tracking_Data

Get_Point

Put_Point

Ada Compiler

Updated Program Library

Vector_Services

Spec

Body

Distance_Between

Sqrt

Calculate_Velocity

Next_Point_After

Compute_Tracking_Data

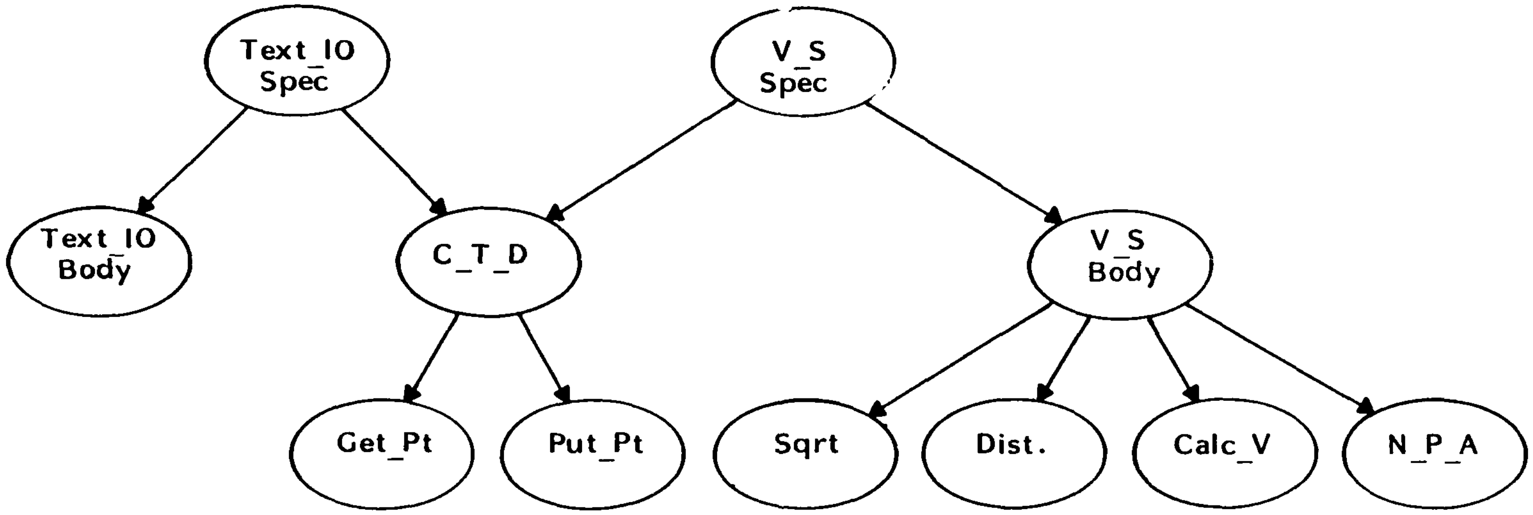
Get_Point

Put_Point

Text_IO

Listings,
Object Code

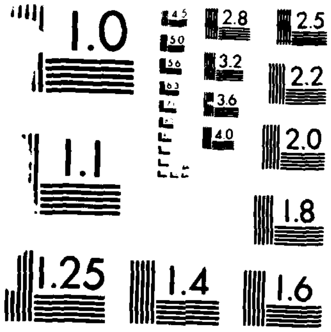
HERE IS THE DEPENDENCY DIAGRAM



ALL POSSIBLE ORDERINGS CAN BE DERIVED FROM THE ABOVE DIAGRAM.

AD-A165 352   ADA (TRADEMARK) TRAINING CURRICULUM: ADA TECHNICAL   2/3
OVERVIEW L102 TEACHER'S GUIDE(U) SOFTECH INC WALTHAM MA
1986 DAAB77-83-C-K506

UNCLASSIFIED   F/G 5/9   NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

IN-CLASS EXERCISE

SUGGEST OTHER COMPILATION ORDER POSSIBILITIES.

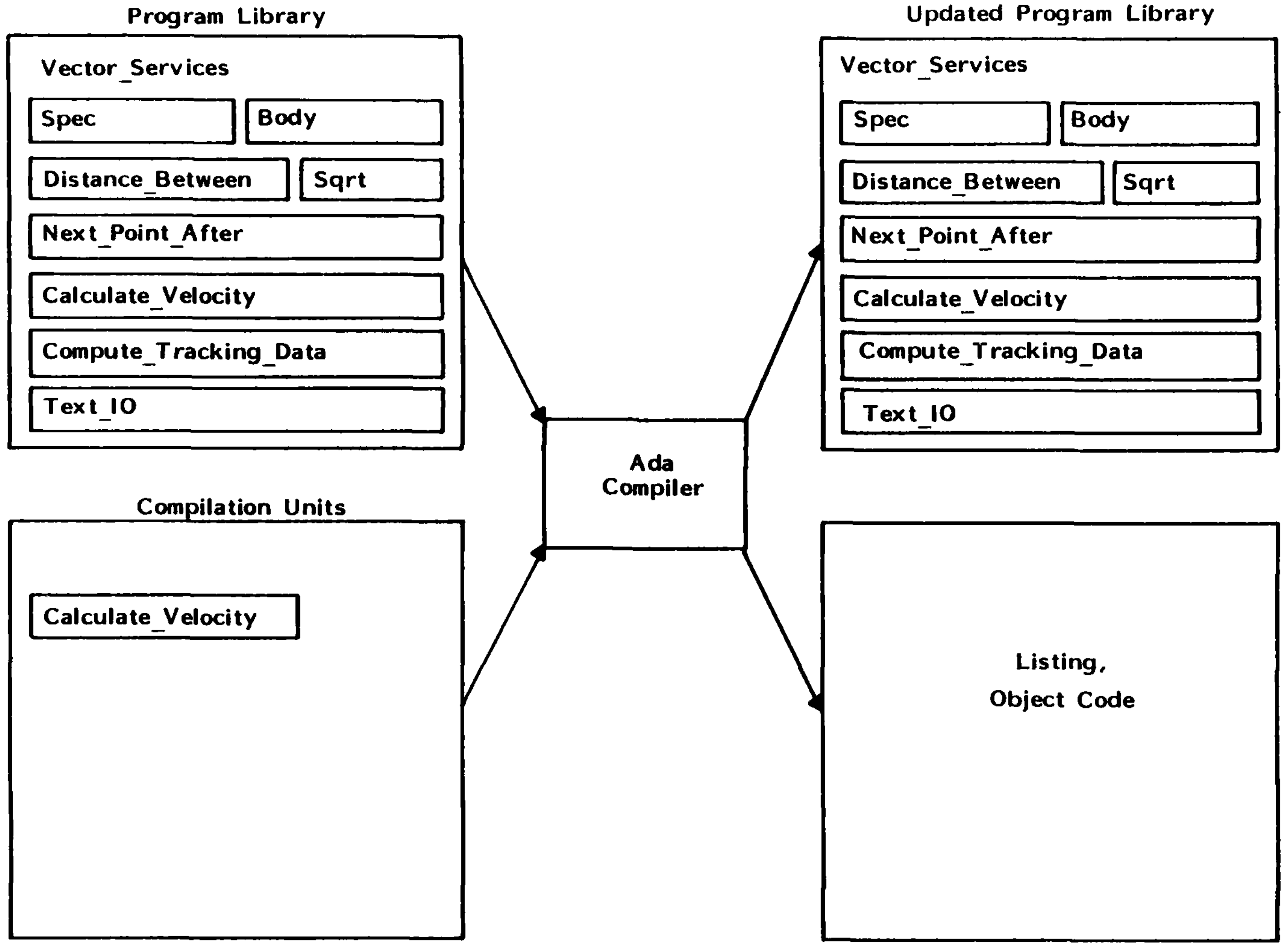
INSTRUCTOR NOTES

SINCE THE PACKAGE SPECIFICATION IS NOT CHANGED, WE DO NOT NEED TO RECOMPILE THE MAIN PROCEDURE.

NOTE, HOW WE REDUCE THE AMOUNT OF MODIFICATION AND RECOMPILING OF THE SYSTEM. ALSO SEVERAL PROGRAMMERS COULD BE WORKING SIMULTANEOUSLY.

CHANGES TO THE SYSTEM: A SUBUNIT

WE MODIFY ONE FUNCTION IN THE PACKAGE BODY.



INSTRUCTOR NOTES

THIS SECTION FORMALIZES ADA PROGRAM STRUCTURE FROM OUR PREVIOUS EXAMPLE.

ALLOW 15 MINUTES FOR THIS SECTION.

Section 3

Summary of Ada Program Structure

INSTRUCTOR NOTES

TOPIC OUTLINE

BACKGROUND AND RATIONALE FOR ADA

WRITING AN ADA PROGRAM FROM BEGIN TO END

SUMMARY OF ADA PROGRAM STRUCTURE

ADA THROUGH EXAMPLE

LARGE SYSTEM DEVELOPMENT

SUMMARY OF ADA FEATURES

FOR MORE INFORMATION

INSTRUCTOR NOTES

A LIST OF THE THREE STRUCTURAL BUILDING BLOCKS OF ANY ADA SYSTEM.

BRIEFLY SAY WHAT EACH DOES IN ADA, E.G. PACKAGES PROVIDE A MEANS TO COLLECT RELATED DATA AND ALGORITHMS, SUBPROGRAMS ARE SIMILIAR TO OTHER LANGUAGES - THEY PROVIDE OUR ALGORITHMS, AND TASKS PROVIDE MECHANISMS FOR REAL TIME PROCESSING.

PROGRAM UNITS

ADA SYSTEMS CAN CONSIST OF COMBINATIONS OF:

- PACKAGES
- SUBPROGRAMS
  - PROCEDURES
  - FUNCTIONS
- TASKS
- GENERICS

INSTRUCTOR NOTES

THE SEPARATION OF THE SPECIFICATION FROM THE BODY (THE WHAT FROM THE HOW) IS WHAT GIVES US THE RELIABILITY AND MAINTAINABILITY POINTS OF THE SLIDE. REALLY EXPLAIN THE SPECIFICATION AND BODY AND WHY IT'S IMPORTANT.

INTERFACE ERRORS ARE ONE OF THE MAJOR PROBLEMS IN INTEGRATING MODULES IN LARGE SYSTEMS. WITH THE SPECIFICATION INFORMATION, THE COMPILER CAN PERFORM VALIDITY CHECKS AT COMPILE-TIME RATHER THAN INTEGRATION TIME. IN OTHER WORDS, YOU CAN TEST THE INTERFACES OF THE DESIGN AS A WHOLE BEFORE CODING ANY OF THE ALGORITHMS. IT IS MORE COST EFFECTIVE TO CORRECT ERRORS AT THIS POINT THAN AT INTEGRATION AND TESTING.

SPECIFICATIONS CAN BE VIEWED AS LOGICAL INTERFACES.

PROGRAM UNIT STRUCTURE

ALL PROGRAM UNITS HAVE A SIMILAR FORM

- SPECIFICATION

  DESCRIBES WHAT THE PROGRAM UNIT DOES

  THIS INFORMATION IS 'VISIBLE' TO (CAN BE REFERENCED BY) THIS AND OTHER PROGRAM UNITS

- BODY

  DETAILS HOW THE PROGRAM UNIT IMPLEMENTS AN ALGORITHM OR STRUCTURE

  THIS INFORMATION IS 'HIDDEN' FROM (CANNOT BE DIRECTLY REFERENCED BY) OTHER PROGRAM UNITS

RELIABILITY INCREASED BECAUSE INTERFACE (SPECIFICATION) ERRORS CAN BE EASILY DETECTED

MAINTAINABILITY INCREASED BECAUSE CHANGES TO THE IMPLEMENTATION (BODY) CAN BE DONE WITHOUT AFFECTING USER PROGRAM UNITS

WE SAW EXAMPLES OF SEPARATE COMPILATION IN THE TRACKING SYSTEM OF SECTION 2.

SEPARATE COMPILATION

BECAUSE OF THE SPECIFICATION/BODY DISTINCTION IN PROGRAM UNITS, LARGE ADA PROGRAMS MAY BE BROKEN INTO PIECES WHICH ARE COMPILED SEPARATELY.

- A COMPILATION CONSISTS OF ONE OR MORE COMPILATION UNITS WHICH ARE SUBMITTED TOGETHER TO THE ADA COMPILER.

- COMPILATION UNITS MAY BE:
  - package specification
  - subprogram specification
  - package body
  - subprogram body
  - subunit

INSTRUCTOR NOTES

EMPHASIZE THAT STUBBING AND SUBUNITS ARE INDIVISABLE.

POINT OUT THAT IT REPRESENTS A MECHANISM FOR TOP DOWN DEVELOPMENT OF LARGE SYSTEMS USING TEAMS OF PROGRAMMERS.

- ALLOWS PROJECTS TO BE SPLIT AMONG SEVERAL PROGRAMMERS, EACH COMPILING THEIR OWN CODE.

- INCREASES READABILITY BY ONLY INCLUDING SPECS OF NESTED SUBPROGRAMS.

SUBUNITS

- THE "TOP DOWN" APPROACH TO SEPARATE COMPILATION INVOLVES USING BODY STUBS AND SUBUNITS.

- AT THE POINT WHERE A SUBPROGRAM BODY OR PACKAGE BODY WOULD NORMALLY APPEAR IN A COMPILATION, A BODY STUB MAY BE USED INSTEAD:

```
procedure Subprogram_Name is separate;
```

  THIS IMPLIES THAT THE ACTUAL BODY WILL BE SUPPLIED IN A SEPARATE SUBUNIT.

- THE BODY IS SUPPLIED WITH A PREFIX INDICTING OR NAMING THE COMPILATION UNIT WHERE THE CORRESPONDING BODY STUB APPEARED

```
separate (Parent_Unit)        -- note no semicolon
procedure Subprogram_Name is  -- body
```

- ALTHOUGH THE SUBUNIT IS SEPARATELY COMPILED, THE EFFECT IS EXACTLY AS IF THE ACTUAL BODY WERE GIVEN AT THE POINT OF THE BODY STUB

INSTRUCTOR NOTES

CAUTION: IT IS VERY IMPORTANT THAT THE INSTRUCTOR BE QUITE FAMILIAR WITH THE FOLLOWING SAMPLE BEFORE PRESENTING THE MATERIAL. ALSO, DO NOT ALLOW THE STUDENTS TO DWELL ON SYNTAX. AT THIS OVERVIEW LEVEL, WE WANT TO CONCENTRATE ON THE CONCEPTS AND RATIONALE FOR ADA FEATURES.

BREAK FOR LUNCH.

ALLOW 30 MINUTES FOR THIS SECTION.

Section 4

Ada Through Example

INSTRUCTOR NOTES

TOPIC OUTLINE

BACKGROUND AND RATIONALE FOR ADA

WRITING AN ADA PROGRAM FROM BEGIN TO END

SUMMARY OF ADA PROGRAM STRUCTURE

ADA THROUGH EXAMPLE

LARGE SYSTEM DEVELOPMENT

SUMMARY OF ADA FEATURES

FOR MORE INFORMATION

INSTRUCTOR NOTES

THE TELEPHONE DIRECTORY SYSTEM IS PRESENTED SINCE IT IS EASY FOR STUDENTS OF ALL BACKGROUNDS TO VISUALIZE HOW IT MIGHT WORK. THUS THE STUDENT CAN CONCENTRATE ON THE ADA NOT THE WORKING OF THE SYSTEM. ASSURE THE STUDENTS THAT THEY WILL BE SEEING THIS MATERIAL SEVERAL TIMES -- IT IS NOT NECESSARY TO GRASP ALL THE FINE POINTS. (LEARNING ADA IS AN ITERATIVE PROCESS. YOU LEARN SOME, TRY TO USE, LEARN SOME MORE ...)

EXAMPLE 2

- DEVELOP A TELEPHONE DIRECTORY SYSTEM FOR YOUR ORGANIZATION
- A USER OF THE DIRECTORY SYSTEM CAN LOOK-UP NAMES, ADD NEW ENTRIES, DELETE ENTRIES, OR LEAVE THE SYSTEM
- THE DATABASE OF THE DIRECTORY SYSTEM CONTAINS THE NAMES AND CORRESPONDING TELEPHONE NUMBERS

INSTRUCTOR NOTES

THE MOTIVATION FOR THE USE OF THE FOLLOWING ADA FEATURES IS PROVIDED THROUGH THE EXAMPLE:

1. PACKAGES
2. ENUMERATION TYPES
3. COMPOSITE TYPES
4. EXCEPTION HANDLER
5. GENERIC INSTANTIATION
6. INTERACTIVE I/O
7. SUBUNITS

A RICHER SET OF DESIGN CONCEPTS

IDENTIFY THE OBJECTS OF THE SYSTEM AND THE OPERATIONS TO BE DONE

OBJECTS	OPERATIONS
USER	MAKE INQUIRIES
	EXIT SYSTEM
DATABASE ENTRIES	LOOK-UP
	ADD
	DELETE

IN TRADITIONAL LANGUAGES WE CAN BUILD MODULES ONLY AROUND THE OPERATIONS (SUBROUTINES). IN ADA WE CAN PACKAGE TOGETHER THE OPERATIONS AND THE OBJECTS THAT ARE AFFECTED.

INSTRUCTOR NOTES

THIS ILLUSTRATES THE FUNCTIONING OF THE DIRECTORY SYSTEM AS A WHOLE.

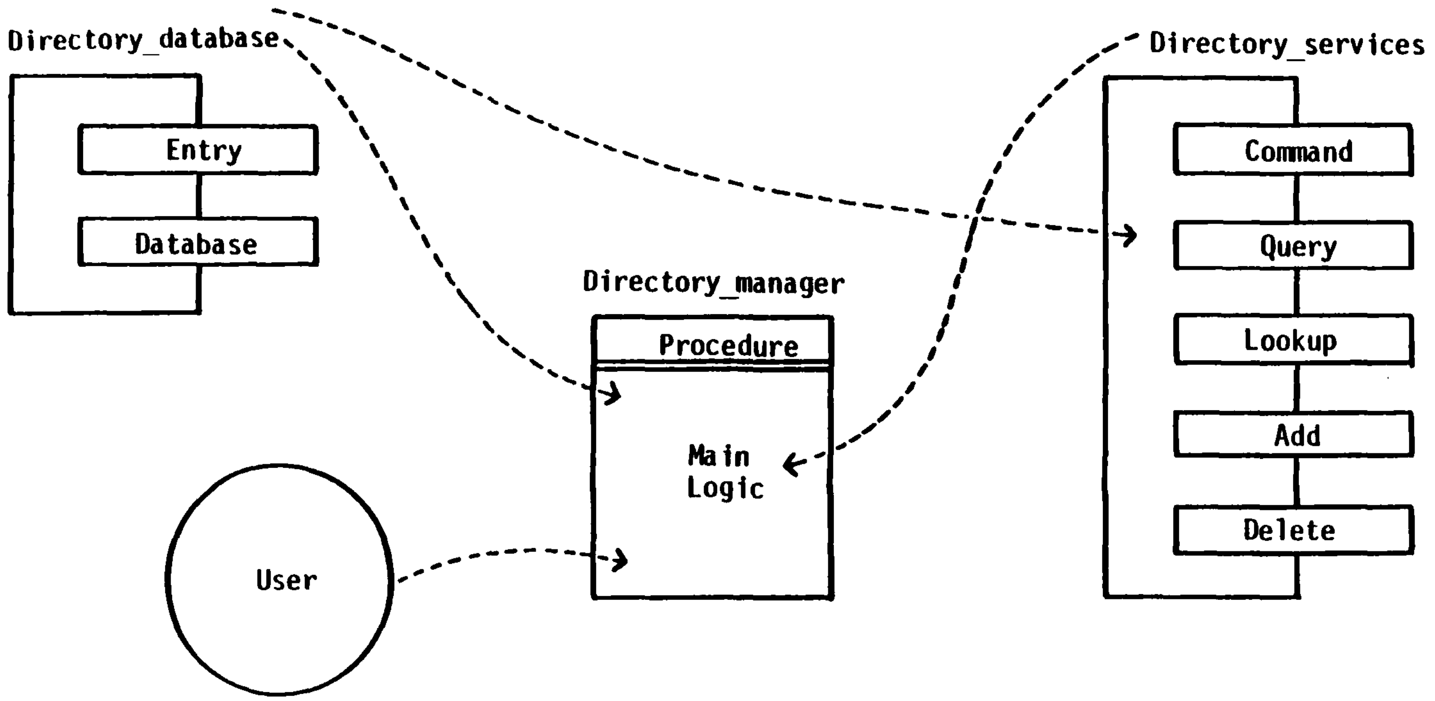
THE DOTTED LINES REFLECT THE INFORMATION DEPENDENCIES OF THE THREE PROGRAM MODULES SHOWN. THE MAIN PROCEDURE AND DIRECTORY_MANAGER NEED INFORMATION FROM THE DIRECTORY DATABASE AND THE DIRECTORY_SERVICES. THE DIRECTORY_SERVICES WILL NEED INFORMATION FROM THE DIRECTORY_DATABASE. NOTE THAT THE DIRECTORY_DATABASE DOES NOT NEED INFORMATION FROM OTHER MODULES, IT JUST PROVIDES INFORMATION TO OTHERS.

THE MAINTAINABILITY BULLET IS IMPORTANT TO EMPHASIZE. THIS BECOMES ONE OF ADA'S BEST FEATURES.

HOW THIS STRUCTURING WAS ARRIVED AT IS OUTSIDE THE SCOPE OF THIS MODULE. THIS MODULE IS LIMITED TO THE DISCUSSION OF PACKAGES WHICH GROUP RELATED DATA STRUCTURES AND/OR OPERATIONS.

IF POSSIBLE, KEEP THIS SLIDE ON SECOND OVERHEAD WHILE GOING THROUGH THE NEXT THREE SLIDES

DEVELOP A PICTORIAL REPRESENTATION OF THE SYSTEM STRUCTURE AND ISOLATE THE INTERFACES



WOULD BE EASY TO ADD/DELETE A SERVICE FOR OUR USERS. WOULD ALSO BE ABLE TO CHANGE THE DATABASE FORMAT WITHOUT DISTURBING OUR SYSTEM = MAINTAINABILITY.

INSTRUCTOR NOTES

THE TRANSLATION OF OUR PICTURE INTO ADA CODE. FIRST, A CONCEPTUALLY PICTURE OF THE CONTENTS OF THE PACKAGE SPECIFICATION AND MAIN PROCEDURE LOGIC ARE PRESENTED FOLLOWED BY THE ACTUAL ADA CODE.

EXPRESS THE DESIGN AS ADA SPECIFICATION

SPECIFICATION:

VISIBLE
PART

```
package Directory_Database is

       -- DESCRIBE WHAT TYPE OF OBJECT EACH ENTRY (NAME, TELEPHONE
       -- NUMBER) IS COMPOSED OF

       -- DESCRIBE WHAT THE DATABASE LOOKS LIKE

       -- THIS INFORMATION CAN BE USED BY THE
       -- PROCEDURE Directory_Manager AND THE
       -- PACKAGE Directory_Services

end Directory_Database;
```

INSTRUCTOR NOTES

THE "with" CONTEXT CLAUSE ALLOWS THE INFORMATION FROM THE PACKAGE LISTED IN THE CLAUSE TO BE REFERENCED BY THE PACKAGE BEING DECLARED. (THIS IS ONLY PARTIALLY TRUE, BUT GETS THE CONCEPT ACROSS.) THIS IS OUR DOTTED LINES ON THE SYSTEM STRUCTURE PICTURE.

INSTRUCTOR SHOULD UNDERLINE RESERVED WORDS. ALSO NOTE THE CODING CONVENTION FOR NAMES.

```
with Directory_Database;      -- OUR INTERFACES

package Directory_Services is

       -- DESCRIBE WHAT OUR COMMAND OBJECT IS

       -- DESCRIBE WHAT OPERATIONS THE USER CAN PERFORM
       -- ON OUR DIRECTORY DATABASE
       -- OUR OPERATIONS ARE QUERY, LOOK-UP, ADD,
       -- AND DELETE
       -- THESE WILL BE EXPRESSED AS SUBPROGRAMS

end Directory_Services;
```

INSTRUCTOR NOTES

```
with Directory_Database, Directory_Services;      -- OUR INTERFACES

procedure Directory_Manager is

begin -- Directory_Manager

       -- THIS IS THE MAIN LOGIC OF OUR SYSTEM
       -- TO OUR DIRECTORY USER

       -- DEPENDING ON THE SERVICE REQUESTED BY OUR
       -- USER, ONE OF THE DIRECTORY SERVICES WOULD
       -- BE PERFORMED OR THE USER CAN EXIT THE
       -- DIRECTORY SYSTEM

end Directory_Manager;
```

INSTRUCTOR NOTES

DON'T EXPLAIN WHAT THESE ARE. JUST TELL THE STUDENT THAT THEY WILL BE DISCUSSED IN CONTEXT.

AS WE COMPLETE OUR ADA SYSTEM WE WILL SEE THE USE OF THE FOLLOWING ADA FEATURES

- TYPES AND DECLARATIONS
- CONTROL STRUCTURES/STATEMENTS
- SUBPROGRAMS
- PACKAGES
- EXCEPTION HANDLERS
- INSTANTIATION OF GENERICS
- INTERACTIVE I/O

INSTRUCTOR NOTES

REITERATE WHAT THIS PACKAGE DOES AND WHAT WE WERE GOING TO PUT IN THIS SPECIFICATION. THEN DISCUSS HOW THAT IS DONE IN THE SLIDE. POINT OUT WHAT THE TYPES ARE, HOW THEY FIT TOGETHER AS A UNIT, WHAT THE PACKAGE CONCEPT DOES, ETC.

"NOW PULLING ALL THIS TOGETHER, WE HAVE..."

```
package Directory_Database is

      type Index is range 1 .. 3000;      --AN INTEGER TYPE
      type Name_Type is                   --A RECORD TYPE
         record
            First          : String (1 .. 10);
            Middle_Initial : String (1 .. 1);
            Last           : String (1 .. 20);
         end record;

      type Telephone_Number_Type is range 1000 .. 4999;

      type Directory_Unit_Record is          --RECORDS ARE LOGICAL DATA STRUCTURES
         record                              --WHICH CAN HAVE DIFFERENT
            Name             : Name_Type;    --TYPES OF THINGS IN THEM
            Telephone_Number : Telephone_Number_Type;
         end record;

      type Database_Type is array (Index) of Directory_Unit_Record;

                                               --AN ARRAY TYPE

end Directory_Database;
```

SAME PROCEDURE AS PREVIOUS SLIDE.

```
with Directory_Database;                           --WE WILL USE WHAT WAS IN THE PACKAGE

package Directory_Services is


   Database : Directory_Database.Database_Type;    -- OBJECT DECLARATION.

   type Command is (Lookup, Add, Delete, Quit);    --AN ENUMERATION TYPE TO REFLECT
                                                   --IN OUR PROGRAMMING LANGUAGE THE
                                                   --REAL WORLD SITUATION

   function Query return Command;

   procedure Lookup_Entry (Data_Name : in Directory_Database.Name_Type);

   procedure Add_To_Database (Data_Record :

                             in Directory_Database.Directory_Unit_Record);

   procedure Delete_From_Database (Data_Name : in Directory_Database.Name_Type);

   procedure Load_Database;

   procedure Store_Database;

end Directory_Services;
```

INSTRUCTOR NOTES

NOTE SAME SORTS OF POINTS AS BEFORE. ALSO NOTE THE READABILITY OF THE CODE (IT'S EASY TO UNDERSTAND).

THE "is separate" ALLOWS FOR SEPARATE DEVELOPMENT AND COMPILATION.

```
with Directory_Database, Directory_Services;
use Directory_Services;                     --WILL LET US USE A SHORT HAND NOTATION WHEN
                                            --WE REFERENCE THE SUBPROGRAM IN THIS PACKAGE

procedure Directory_Manager is

   Local_Data_Record: Directory_Database.Directory_Unit_Record;

   procedure Input_Data (Data_Record :
       out Directory_Database.Directory_Unit_Record) is separate; --WE WOULD FIND
                                            --THE CODE SOME PLACE ELSE
                                            --THIS ALLOWS FOR SEPARATE DEVELOPMENT AND
                                            --COMPILATION

begin -- Directory_Manager
   Load_Database;
   loop

      case Query is                         --A CASE STATEMENT PROVIDES MULTIPLE STATES
                                            --TO BE HANDLED IN ONE STATEMENT

         when Lookup => Input_Data (Local_Data_Record);
                        Lookup_Entry (Local_Data_Record.Name);

         when Add    => Input_Data (Local_Data_Record);
                        Add_To_Database (Local_Data_Record);

         when Delete => Input_Data (Local_Data_Record);
                        Delete_From_Database (Local_Data_Record.Name);

         when Quit   => exit;               -- EXIT FROM LOOP

      end case;

   end loop;
   Store_Database;
end Directory_Manager;
```

INSTRUCTOR NOTES

A SPECIFICATION USUALLY HAS A BODY, SO WE COMPLETE OUR SYSTEM FURTHER.

IN SKELETAL FORM OUR SPECIFICATION AND BODY FOR THE DATABASE PACKAGE.

REMIND THE STUDENTS WHAT THE SPECIFICATION AND BODY EACH DO.

IMPLEMENT THE PACKAGE BODIES

SPECIFICATION

```
package Directory_Database is
-- DECLARATIONS FOR OUR DATABASE STRUCTURE
end Directory_Database;
```

BODY

NONE NEEDED FOR THIS PACKAGE SPECIFICATION

INSTRUCTOR NOTES

TO SHOW THE STRUCTURE OF THE PACKAGE BODY ... NESTING OF OTHER PROGRAM UNITS.

```
with Directory_Database;
package Directory_Services is

      -- SPECIFICATIONS OF SERVICE ROUTINES

end Directory_Services;

with Text_IO;
package body Directory_Services is

      -- ANY ADDITIONAL DATA OR SUBPROGRAM DECLARATIONS
      -- NEEDED FOR THE IMPLEMENTATION

      procedure Lookup_Entry (Data_Name : in Directory_Database.Name_Type) is separate;

      -----------

      function Query return Command is separate;

      procedure Add_To_Database (Data_Record:

                           in Directory_Database.Directory_Unit_Record) is separate;

      procedure Delete_From_Database (Data_Name: in Directory_Database.Name_Type) is separate;

      procedure Load_Database is separate;

      procedure Store_Database is separate;

end Directory_Services;
```

INSTRUCTOR NOTES

TO ILLUSTRATE SOME "EXECUTABLE" ADA CODE FOR ONE PROCEDURE ONLY.

```
separate (Directory_Services)     --THE PARENT UNIT
procedure Lookup_Entry (Data_Name : in Directory_Database.Name_Type) is

      Found : Boolean := False;   --INITIALIZATION AND OBJECT DECLARATION CAN BE COMBINED
      package Int_IO is new Text_IO.Integer_IO (Directory_Database.Telephone_Number_Type);
         use Int_IO;
         use Directory_Database;

begin --Lookup_Entry

      for I in Database'Range loop

            if Database(I).Name = Data_Name then

               Text_IO.Put ("Telephone number is");  --THIS WRITES A MESSAGE TO OUR USER
               Int_IO.Put (Database(I).Telephone_Number);

                                                     -- FOLLOWED BY THE REQUESTED PHONE
                                                     -- NUMBER

               Found := True;

               exit;       -- EXIT THE FOR LOOP

            end if;

      end loop;

      if not Found then

         Text_IO.Put ("Name not found");

      end if;

end Lookup_Entry;
```

INSTRUCTOR NOTES

FUNCTION QUERY...

THIS FUNCTION WILL PERFORM OUR QUERY WITH THE USER. NOTE THE USE OF ENUMERATION TYPE COMMAND, THE GENERIC INSTANTIATION FOR I/O (TELL THEM WHY THIS IS DESIRABLE - I.E. USER HAS COMPLETE CONTROL OVER I/O), THE EXCEPTION HANDLER, AND USER-FRIENDLY INTERACTION.

```
separate (Directory_Services)
function Query return Command is
     Query_State: Command;
     package Command_IO is new Text_IO.Enumeration_IO (Command);
                         --GENERIC INSTANTIATION GIVES OUR PROGRAM
                         --A COPY OF THE I/O PACKAGE NEEDED FOR ONE
                         --ENUMERATION TYPE

     use Command_IO;

begin -- Query

     loop    --LET'S US PROVIDE FOR INPUT COMMAND ERRORS SO USER CAN HAVE
             --MULTIPLE CHANCES TO ENTER A VALID COMMAND WITHOUT CRASHING THE SYSTEM

        begin

            Text_IO.New_Line;

            Text_IO.Put ("Enter Command (Lookup, Add, Delete, Quit):");

            Get (Query_State);

            return Query_State;

        exception            --EXCEPTION HANDLER FOR INPUT COMMAND ERRORS

          when Text_IO.Data_Error => Text_IO.Put ("Invalid Command, Try again.");

        end;

     end loop;

end Query;
```

INSTRUCTOR NOTES

ONE OF THE LANGUAGE GOALS FOR ADA WAS TO PROVIDE FACILITIES FOR THE DEVELOPMENT OF SOFTWARE BY A LARGE NUMBER OF PEOPLE. THE MAJORITY OF DoD CONTRACTS ARE OF THIS NATURE. THIS SECTION WILL HIGHLIGHT HOW THIS IS DONE IN ADA.

ALLOW 30 MINUTES FOR THIS SECTION.

Section 5

Large System Development

INSTRUCTOR NOTES

TOPIC OUTLINE

BACKGROUND AND RATIONALE FOR ADA

WRITING AN ADA PROGRAM FROM BEGIN TO END

SUMMARY OF ADA PROGRAM STRUCTURE

ADA THROUGH EXAMPLE

LARGE SYSTEM DEVELOPMENT

SUMMARY OF ADA FEATURES

FOR MORE INFORMATION

INSTRUCTOR NOTES

UNDERLYING ALL LARGE SYSTEMS DEVELOPMENT REQUIREMENTS IS THE ABILITY TO HAVE MANY PROGRAMMERS WORKING SIMULTANEOUSLY. TO HAVE THAT YOU NEED THE FOUR SUB-POINTS.

DEVELOPMENT OF LARGE SYSTEMS

- PROGRAMMERS NEED TO WORK CONCURRENTLY
  - RICH VARIETY OF MODULES
  - IMPLEMENTATION STRATEGIES
  - SEPARATE COMPILATION
  - NAME SPACE CONTROL

INSTRUCTOR NOTES

DESIGN MODULES

- In FORTRAN,

  A MODULE ≈ A SUBROUTINE

- *In ADA,*

  A MODULE ≈ A PROGRAM UNIT

INSTRUCTOR NOTES

ADA PROGRAM UNITS

- ADA PROVIDES GREATER VARIETY OF REPRESENTATION OF DESIGN MODULES
  - PROCEDURE/FUNCTIONS (ALGORITHMS)
  - PACKAGES (ABSTRACT DATA TYPES)
  - TASKS (PARALLEL ACTIONS)
  - GENERICS (REUSABLE COMPONENTS)
- THIS ALLOWS ADA TO SUPPORT DIFFERENT DESIGN STYLES
  - DATA FLOW ORIENTED
  - DATA STRUCTURE ORIENTED
  - OBJECT-ORIENTED

INSTRUCTOR NOTES

REMIND THE STUDENTS WHAT "LIBRARY UNITS" ARE.

BOTTOM-UP IMPLEMENTATION

THROUGH REUSABLE LIBRARY UNITS

```
      package Directory_Database is

                     -- THE LIBRARY UNIT

      end Directory_Database;


      with Directory_Database, Directory_Services;  --"CONTEXT SPECIFICATION" ALLOWS
      procedure Directory_Manager is                -- SERVICES (OPERATIONS) AVAILABLE
                                                    -- IN THE LIBRARY UNIT TO BE USED
                                                    -- BY THIS PROGRAM UNIT

           ...

      end Directory_Manager;
```

INSTRUCTOR NOTES

INDICATE THE STUBS.

NOTE ALSO, NO SEMICOLON AFTER separate (Directory_Services).

TOP-DOWN IMPLEMENTATION

THROUGH SUBUNITS (STUBS)

PARENT UNIT

```
with Text_IO;
package body Directory_Services is
   ...
   procedure Lookup_Entry (Data_Name:
              in Directory_Database.Name_Type) is separate;
   ...
end Directory_Services;
```

SUBUNIT

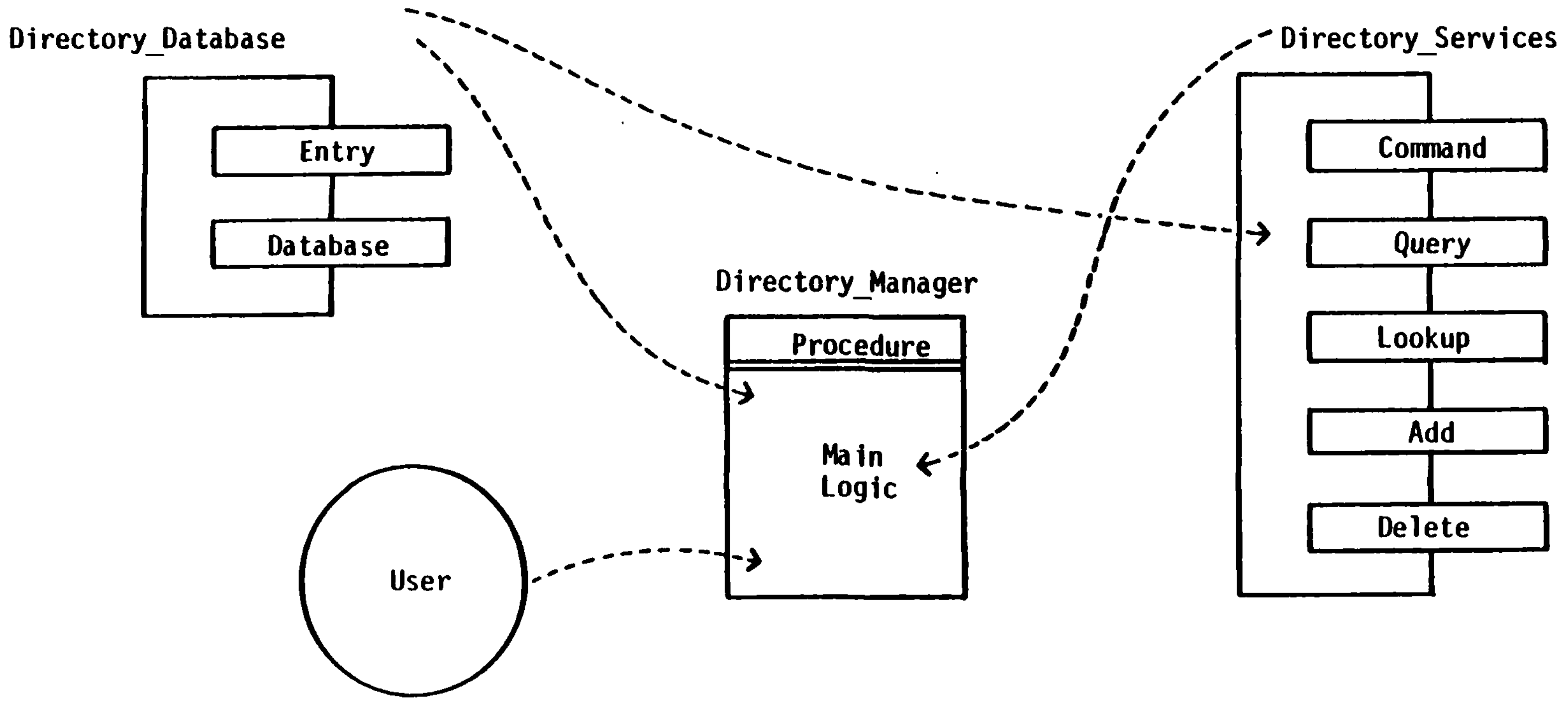
```
separate (Directory_Services)
procedure Lookup_Entry (Data_Name:
              in Directory_Database.Name_Type is

 ...
begin -- Lookup_Entry

 ...

end Lookup_Entry;
```

INSTRUCTOR NOTES

PURPOSE OF SEPARATE COMPILATION

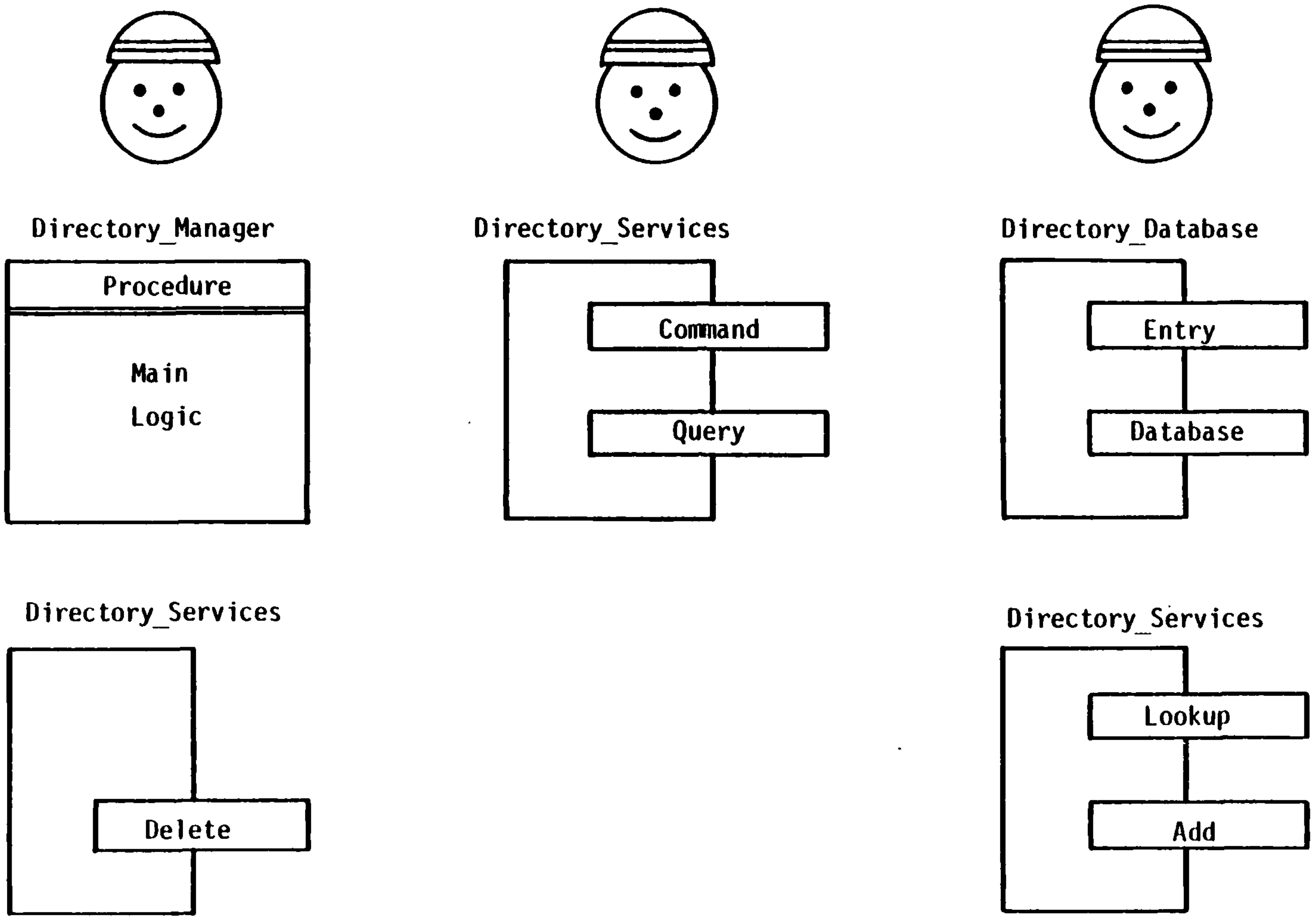
- ALLOWS SEVERAL PEOPLE TO IMPLEMENT A SYSTEM,

  FOR EXAMPLE:



INSTRUCTOR NOTES

SEPARATE COMPILATION (Continued)



Directory_Manager

Procedure

Main Logic

Directory_Services

Command

Query

Directory_Database

Entry

Database

Directory_Services

Delete

Directory_Services

Lookup

Add

INSTRUCTOR NOTES

CONTROL OVER ENTITY NAMES

- SCOPE/VISIBILITY RULES
- OVERLOADING

INSTRUCTOR NOTES

PURPOSE OF SCOPE AND VISIBILITY RULES

- SCOPE RULES CONTROL THE LIFE TIME OF ENTITIES

  FOR EXAMPLE:

  WHEN STORAGE CAN BE RECLAIMED

- VISIBILITY RULES PREVENT ACCIDENTAL NAME CONFLICTS

  FOR EXAMPLE:

  DIFFERENT SUBPROGRAMS CAN HAVE "LOCAL" VARIABLES NAMED TEMP

INSTRUCTOR NOTES

PURPOSE OF OVERLOADING

COMMON NAMES TO REFLECT SIMILAR FUNCTIONS

```
Put ("Name not found");

Put (Command);
```

INSTRUCTOR NOTES

THIS SECTION PRESENTS THE DESIGN CRITERIA FOR THE ADA LANGUAGE AND A GENERAL OVERVIEW OF THE FEATURES AND CONSTRUCTS THAT MAKE UP THE LANGUAGE. PROVIDES A "FEEL" FOR THE SCOPE OF THE FEATURES AVAILABLE IN THE LANGUAGE.

ALLOW 60 MINUTES FOR THIS SECTION.

BREAK HERE FOR 15 MINUTES.

Section 6

Summary of Ada Features

INSTRUCTOR NOTES

TOPIC OUTLINE

BACKGROUND AND RATIONALE FOR ADA

WRITING AN ADA PROGRAM FROM BEGIN TO END

SUMMARY OF ADA PROGRAM STRUCTURE

ADA THROUGH EXAMPLE

LARGE SYSTEM DEVELOPMENT

SUMMARY OF ADA FEATURES

FOR MORE INFORMATION

INSTRUCTOR NOTES

THE FIRST THREE LANGUAGE REQUIREMENTS FROM THE STEELMAN DOCUMENT ARE GIVEN. (OTHERS ARE EFFICIENCY, SIMPLICITY, IMPLEMENTATION. THESE LAST THREE COULD BE QUITE CONTROVERSIAL AS TO WHETHER ADA ACTUALLY SATISFIES ITS OWN REQUIREMENTS.)

LIST IS IN ORDER OF IMPORTANCE OF DESIGN CRITERIA. SHOULD NOTE THAT RELIABILITY IS MORE IMPORTANT THAN EFFICIENCY. ALSO THAT READABILITY IS MORE IMPORTANT THAN WRITABILITY - A PROGRAM IS READ MANY MORE TIMES IN ITS LIFE TIME THAN IT IS WRITTEN.

MODERN SOFTWARE ENGINEERING PRINCIPLES INCLUDE MODULARITY, ABSTRACTION, LOCALIZATION, HIDING, UNIFORMITY, COMPLETENESS, CONFIRMABILITY. INSTRUCTOR SHOULD BE FAMILIAR WITH THESE CONCEPTS. (EXCELLENT REFERENCE IF THE INSTRUCTOR NEEDS THIS BACKGROUND: "SOFTWARE ENGINEERING: PROCESS, PRINCIPLES, AND GOALS", D.T. ROSS, J.B. GOODENOUGH, C.A. IRVINE, COMPUTER, MAY 1975).

THE ADA LANGUAGE WAS DESIGNED FOR

- GENERALITY

  MEETS A WIDE SPECTRUM OF NEEDS

- RELIABILITY

  PROVIDES COMPILE-TIME DETECTION OF CODING ERRORS

  ENCOURAGES MODERN SOFTWARE ENGINEERING PRINCIPLES

- MAINTAINABILITY

  READABILITY IS MORE IMPORTANT THAN WRITABILITY

  ENCOURAGES DOCUMENTATION

- MACHINE INDEPENDENCE

  IMPLEMENTATION DEPENDENT LANGUAGE FEATURES CLEARLY IDENTIFIED

INSTRUCTOR NOTES

ECS IS A COMPUTER FOUND IN THE CONTEXT OF A LARGER SYSTEM POSSIBLY NON-COMPUTER ITEMS - E.G. RADAR, MICRO WAVE OVENS, MISSILES, SPACE SHUTTLE. IT IS NOT DATA PROCESSING BUT REAL TIME SYSTEMS WHICH MUST INTERACT WITH AN EXTERNAL ENVIRONMENT.

ECS NEEDS PARALLEL PROCESSING, REAL TIME CONTROL, ERROR HANDLING, UNIQUE I/O CONTROL. IT GENERALLY DEALS WITH SYSTEMS THAT ARE LARGE, WILL BE IN EXISTENCE FOR MANY YEARS, AND UNDERGO CONTINUAL MODIFICATIONS. RELIABILITY AND SIZE CONSTRAINTS ARE CRITICAL FACTORS IN MOST ECS. E.G. - YOU CAN'T AFFORD TO HAVE AN ERROR IN S/W FOR NUCLEAR MISSILES.

AS A RESULT NOTE THAT REAL TIME SYSTEM PROCESSING AND SEPARATE COMPILATION FACILITIES FOR LARGE SYSTEM DEVELOPMENT WERE STRESSED. ALSO S/W ENGINEERING METHODS AND PRINCIPLES SUCH AS STRONG-TYPING, ABSTRACTION, HIDING, STRUCTURED PROGRAMMING WERE EMPHASIZED AS REQUIREMENTS FOR A LANGUAGE.

DoD LANGUAGE REQUIREMENTS

SOFTWARE ENGINEERING	STRONG TYPING
	DATA ABSTRACTION AND INFORMATION HIDING
	STRUCTURED CONTROL CONSTRUCTS
EMBEDDED COMPUTER SYSTEMS	CONCURRENT PROCESSING
	ERROR HANDLING
	MACHINE REPRESENTATION FACILITIES
LARGE SYSTEM DEVELOPMENT	SEPARATE COMPILATION AND LIBRARY MANAGEMENT
REUSABLE SOFTWARE	GENERIC DEFINITION

INSTRUCTOR NOTES

THE FOLLOWING PROVIDES A FORMAL SUMMARY OF THE ACTUAL LANGUAGE. THE STUDENT NOW HAS A CONTEXT FOR THE OVERVIEW. AGAIN THE EMPHASIS IS TO GIVE A FAMILIARITY WITH ADA TERMS NOT NECESSARY TO BE ABLE TO READ ADA PROGRAMS.

THE LISTED ADA FEATURES WILL BE DISCUSSED. FOR EACH A DEFINITION AND ITS IMPORTANCE TO OUR SOFTWARE OBJECTIVES IS PRESENTED. THE APPROACH IS TOP-DOWN. "ADDITIONAL FEATURES" COMPRISES OTHER ADA FEATURES SUCH AS GENERICS, OVERLOADING, MACHINE REPRESENTATION SPECIFICATIONS, AND I/O.

AS THIS IS A SUMMARY, THE PACE CAN BE FAIRLY BRISK.

CATALOGUE OF ADA FEATURES

- PACKAGES
- SUBPROGRAMS
- TASKS
- STATEMENTS
- DECLARATIONS
- TYPES
- LEXICAL RULES
- GENERICS
- OVERLOADING
- EXCEPTIONS
- MACHINE REPRESENTATION SPECS
- I/O

INSTRUCTOR NOTES

THIS IS ONE OF ADA'S STRONGEST FEATURES.

PACKAGES PROVIDE A MEANS TO PHYSICALLY GROUP LOGICALLY RELATED OBJECTS AND OPERATIONS IN SUCH A WAY THAT WHEN WE NEED TO CHANGE PORTIONS OF A SYSTEM WE CAN KNOW THE EXACT AREAS THAT WILL BE AFFECTED. THUS WE CAN REDUCE THE AFFECTED AREA TO A MINIMUM. THIS ALLOWS US CONTROL OF THE PROVERBIAL "RIPPLE EFFECT" ASSOCIATED WITH SYSTEM CHANGES.

PACKAGES

- ARE BASIC STRUCTURING UNITS
- GROUP FUNCTIONALLY RELATED DATA AND PROGRAM UNITS (ENCAPSULATION)
- ARE STRUCTURE REPRESENTATIONS, NOT ALGORITHMS
- PROVIDE FOR REUSABLE SOFTWARE COMPONENTS
- INCREASE MAINTAINABILITY BECAUSE EFFECT OF CHANGES CAN BE LOCALIZED

SUBPROGRAMS

- BASIC EXECUTABLE PROGRAM UNITS
- TWO FORMS OF SUBPROGRAMS

  PROCEDURE

  - CALLED BY A STATEMENT

  FUNCTION

  - CALLED IN AN EXPRESSION, ALWAYS RETURNS 1 RESULT

- SUBPROGRAM PARAMETERS PASS <u>VALUES</u>

INSTRUCTOR NOTES

TASKS PROVIDE EXPRESSION OF REAL TIME PROCESSING IN A HIGH ORDER LANGUAGE (HOL).

RENDEZVOUS PROVIDES SYNCHRONIZATION AND THE EXCHANGE OF DATA.

TASKS

- PARALLEL THREADS OF CONTROL
- CONCURRENCY REAL WITH MULTIPROCESSORS; CONCURRENCY APPARENT WITH SINGLE PROCESSOR
- MECHANISM FOR SYNCHRONIZATION AND DATA TRANSMISSION IS CALLED "RENDEZVOUS"
- DIRECT MAPPING OF REAL TIME PROCESSING DESIGNS INTO THE LANGUAGE

INSTRUCTOR NOTES

THIS IS A SAMPLE TASK PROGRAM UNIT. DON'T GO INTO ANY DETAIL, JUST INDICATE ITS SIMILARITIES TO A PROCEDURE.

TASKS

```
task Card_Reader is
   entry Get (C: out Card);
end Card_Reader;
task body Card_Reader is
   Latest_Card: Card;
begin -- Card_Reader
   loop
      Text_IO.Get (Latest_Card);
      accept Get (C: out Card) do
          C := Latest_Card;
      end Get;
   end loop;
end Card_Reader;
```

INSTRUCTOR NOTES

DON'T GO INTO THE INDIVIDUAL LISTS OF STATEMENTS. JUST SHOW THAT STATEMENTS EXIST TO HANDLE THE LISTED AREAS OF ACTION AND CONTROL (I.E. FLOW CONTROL, BASIC ACTIONS, REAL TIME ACTIONS, EXCEPTIONS).

NOTE THAT THIS IS ALL THE STATEMENTS THERE ARE TO LEARN IN ADA AND THE STATEMENTS ARE SIMILIAR TO OTHER LANGUAGES.

STATEMENTS

```
if Largest_Value < List (Index) then
   Largest_Value := List (Index);
end if;
```

- PROVIDE LOGIC CONTROL OR SPECIFIC ACTIONS

FLOW CONTROL:	GOTO IF (CONDITIONAL) CASE (CONDITIONAL) LOOP & EXIT (ITERATIVE) RETURN EXCEPTION HANDLERS
BASIC ACTIONS:	SUBPROGRAM CALLS EXPRESSIONS ASSIGNMENT RAISE (EXCEPTIONS)
REAL TIME ACTION:	ENTRY CALL ACCEPT ABORT DELAY SELECT
EXCEPTIONS:	RAISE
DECLARATION SCOPE:	BLOCK

INSTRUCTOR NOTES

OBJECT DECLARATIONS

```
Largest_Value: Scores_Type;
```

- ASSOCIATE A NAME WITH AN OBJECT
- ALL OBJECTS MUST BE EXPLICITLY DECLARED
- CONSTANT OBJECTS
- VARIABLE OBJECTS
- DYNAMICALLY CREATED OBJECTS (AT RUN TIME)

CHOICE OF APPROPRIATE NAMES TO ACCURATELY REFLECT THE OBJECTS USE CAN GREATLY IMPROVE THE UNDERSTANDABILITY OF A SYSTEM AND THUS MAINTAINABILILTY (THEREFORE DECREASE COSTS).

INSTRUCTOR NOTES

TYPE IS CONFUSING TO MANY PEOPLE WITH ONLY A FORTRAN OR ASSEMBLY LANGUAGE BACKGROUND. SIMPLY, A TYPE IS JUST A TEMPLATE, A DESCRIPTION OF HOW SOME OBJECT WILL BEHAVE, BUT IT DOESN'T CREATE THE OBJECT IN MEMORY. A DECLARATION THEN DOES THE ACTUAL CREATION. (NOTE THE CONNECTION OF TYPE AND DECLARATION.)

EMPHASIZE STRONG TYPING ADVANTAGES AND THE EXAMPLES (BRIEFLY). IT MAKES IT SO YOU CAN'T MIX APPLES AND ORANGES ACCIDENTALLY. IF YOU WOULD NORMALLY NOT COMBINE OBJECTS (SAY IN THE REAL WORLD) THAT LOGIC CAN BE REFLECTED IN THE LANGUAGE. (THIS IS AN IMPORTANT PART OF ADA.)

TYPES

```
Type List_Type is array (1 .. 15) of Scores_Type;
```

- A TEMPLATE TO DESCRIBE (NOT CREATE)
  - A SET OF VALUES
  - THE OPERATIONS APPLICABLE TO THOSE VALUES
- PREDEFINED AND USER-DEFINED TYPES
- STRONG TYPING ALLOWS ERROR DETECTION AT COMPILE-TIME
  - THE TYPE OF A VARIABLE OR PARAMETER DOES NOT CHANGE ONCE CREATED

```
Amount_Of_Gold: Pounds;
Amount_In_Glass: Ounces;
Amount_In_Glass := Amount_Of_Gold + 1;          -- ILLEGAL
```

- INCREASED RELIABILITY BECAUSE LANGUAGE CAN BE USED
  - TO PROHIBIT OBJECTS OF DIFFERING LOGICAL TYPES FROM BEING MIXED
  - TO EXPLICITLY STATE DESIGN COSTRAINTS

INSTRUCTOR NOTES

ADA IS A READABLE, SENSIBLE LANGUAGE.

POINT OUT THAT THERE ARE CODING CONVENTIONS, FOR EXAMPLE, YOU DON'T JUST RANDOMLY INDENT.

GENERAL LEXICAL RULES

- FREE FORMAT FOR READABILITY

  INDENTATION TO SHOW LOGICAL NESTING
  SPACES, BLANK LINES PERMITTED
  NO CONTINUATION SYMBOL

- COMMENTS

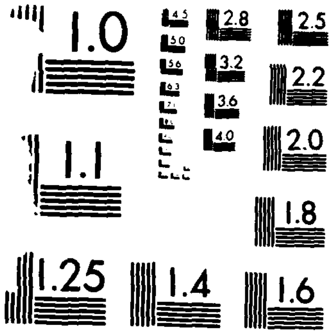
  -- TWO DASHES INDICATE START OF COMMENT

  A COMMENT TERMINATES AT END OF LINE

- UPPER/LOWER CASE PLUS UNDERSCORE (_) USED IN NAMES FOR READABILITY

AD-A165 352 ADA (TRADEMARK) TRAINING CURRICULUM: ADA TECHNICAL OVERVIEW L102 TEACHER'S GUIDE(U) SOFTECH INC WALTHAM MA 1986 DAAB77-83-C-K506 3/3

UNCLASSIFIED F/G 5/9 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

INSTRUCTOR NOTES

ADDITIONAL ADA FEATURES

INSTRUCTOR NOTES

GENERICS ARE SIMILAR TO MACROS BUT MACROS ARE COMPILE-TIME CONCEPTS, GENERICS ARE RUNTIME.

DIFFERENCE BETWEEN GENERICS AND SUBPROGRAMS:

SUBPROGRAMS CAN PASS ONLY VALUES AS PARAMETERS

GENERICS CAN PASS TYPES OF DATA AS WELL AS VALUES AND SUBPROGRAMS AS PARAMETERS

REUSABLE PROGRAM UNITS/SOFTWARE COMPONENTS CAN BE AN EFFECTIVE METHOD OF REDUCING OVERALL SOFTWARE COSTS ... BUT REQUIRES THOUGHT AND PLANNING.

GENERIC UNITS

- PROBLEMS THAT DIFFER ONLY IN TYPES OF DATA NEED ONLY BE SOLVED ONCE

  EXAMPLE:

  SORT A LIST OF NAMES

  SORT A LIST OF NUMBERS

- PARAMETERIZED TEMPLATES FOR SUBPROGRAMS OR PACKAGES (NOT EXECUTABLE)

- "INSTANTIATION: CREATES AN EXECUTABLE COPY OF THE PROGRAM UNIT AND SUBSTITUTES THE PARAMETERS

- REUSABLE PROGRAM UNITS

INSTRUCTOR NOTES

GENERICS

```
generic
   Size : Positive;
   type Item is private;
package Stack is
   procedure Push (E : in Item);
   procedure Pop  (E : out Item);
   Overflow, Underflow : exception;
end Stack;

package body Stack is

   type Table is array (Positive range <>) of Item;
   Space : Table (1 .. Size);
   Index : Natural  := 0;

   procedure Push(E  : in Item) is
   begin
      if Index >= Size then
         raise Overflow;
      end if;
      Index  := Index + 1;
      Space(Index)  := E;
   end Push;

   procedure Pop(E  : out Item)is
   begin
      if Index = 0 then
         raise Underflow;
      end if;
      E  := Space(Index);
      Index  := Index - 1;
   end Pop;

end Stack;
```

Instances of this generic package can be obtained as follows:

```
   package Stack_Int  is new Stack(Size => 200, Item  => Integer);
   package Stack_Bool is new Stack(100, Boolean);
```

INSTRUCTOR NOTES

THIS IS REALLY A FAMILIAR CONCEPT FROM OTHER LANGUAGES. WE OVERLOAD THE ADDITION OPERATOR (+) BY USING IT FOR INTEGER ADDITION AS WELL AS FOR REAL NUMBER ADDITION. WE CAN FURTHER OVERLOAD THE ADDITION OPERATOR TO ADD TWO MATRICES.

ADA JUST EXTENDS THIS POWER.

OVERLOADING

- CONCEPT OF ONE ENTITY NAME REPRESENTING TWO OR MORE ENTITIES

```
Put ("Median of Scores is ");
Put (Median);
```

- MOST LANGUAGES HAVE OPERATOR OVERLOADING. ADA EXTENDS THIS TO IDENTIFIER NAMES, SUBPROGRAMS, OPERATORS.

- ALLOWS PROGRAMMERS TO CHOOSE NAMES APPROPRIATE TO THEIR USE (THE ABSTRACTION) AS LONG AS AMBIGUITY CAN BE RESOLVED BY CONTEXT

INSTRUCTOR NOTES

IN REAL TIME SYSTEMS YOU CAN'T AFFORD TO ALLOW A SYSTEM TO CRASH BECAUSE SOME "IMPOSSIBLE" STATE WAS REACHED AT SOME POINT IN THE PROGRAM. EXCEPTIONS ALLOW FOR POSSIBLE CORRECTION AND RESUMED EXECUTION, OR AT LEAST A GRACEFUL EXIT FROM EXECUTION.

NOTE:

> *EXCEPTIONS ARE NOT JUST FOR ERROR CONDITIONS.* THEY CAN BE USED TO INDICATE WHEN SOME SPECIFIC STATE IS REACHED AND TO BRING THIS TO THE ATTENTION OF THE PROGRAM FOR HANDLING. (BACKGROUND, ONLY).

EXCEPTIONS

- AN EXCEPTION STOPS SEQUENTIAL EXECUTION WHEN A PARTICULAR CONDITION IS REACHED, AND TRANSFERS CONTROL TO SOME KNOWN LOCATION WHERE THE CONDITION MAY BE HANDLED

- A MECHANISM FOR FAULT-TOLERANT PROGRAMMING

    ALTERNATIVE TO EXPLICIT ERROR CODE PARAMETERS

- PREDEFINED AND USER-DEFINED EXCEPTIONS

- AID TO RELIABILITY

INSTRUCTOR NOTES

EXCEPTION

```
begin

   ...

exception               --EXCEPTION HANDLER

   when Division_By_Zero =>

      ...

   when others  =>

      ...

end;
```

INSTRUCTOR NOTES

THE LAST 2 BULLETS ARE THE MAIN IMPACT, THRUST OF THIS FACILITY.

FACILITY IS PRIMARILY NEEDED FOR ECS USE (ONLY SPECIALIZED FEW WILL NEED TO USE THIS FEATURE).

BY ENCAPSULATING THE MACHINE DEPENDENT CODE, THE SYSTEM IS EASIER TO MAINTAIN OR RETARGET BECAUSE THE AREAS OF NECESSARY CHANGE ARE LOCALIZED AND IDENTIFIED.

MACHINE REPRESENTATION SPECIFICATIONS

```
for Vehicle_Record'Size use 1000;
```

- MAPS AN OBJECT DESCRIPTION (A TYPE) ONTO ACTUAL HARDWARE
- CREATES INTERFACES WITH FEATURES OUTSIDE THE LANGUAGE (E.G. INTERRUPTS, I/O DEVICES)
- ALLOWS USER TO INTERFACE WITH HARDWARE PERIPHERALS WHILE REMAINING IN HIGH ORDER LANGUAGE
- ENCAPSULATE FOR PORTABILITY, MAINTAINABILITY

INSTRUCTOR NOTES

IF YOUR PART OF A SYSTEM HAS SPECIFIC OR LIMITED I/O NEEDS, THEN YOU ONLY HAVE TO HAVE WHAT IS ABSOLUTELY NECESSARY TO YOUR PARTICULAR FUNCTION. YOU DON'T HAVE TO HAVE ALL POSSIBLE FORMS/FORMATS OF I/O FOR ALL POSSIBLE USES. DECREASES COMPILE OVERHEAD.

INPUT/OUTPUT

- ACCESSED THROUGH PACKAGES (PREDEFINED AND USER-DEFINED)
- USER HAS COMPLETE CONTROL OF I/O
- PREDEFINED I/O
    - LOW-LEVEL I/O
    - HIGH-LEVEL I/O
        - TEXT I/O
        - DIRECT I/O
        - SEQUENTIAL I/O

INSTRUCTOR NOTES

A SUMMARY OF WHAT/WHERE/WHY ADA IS USEFUL.

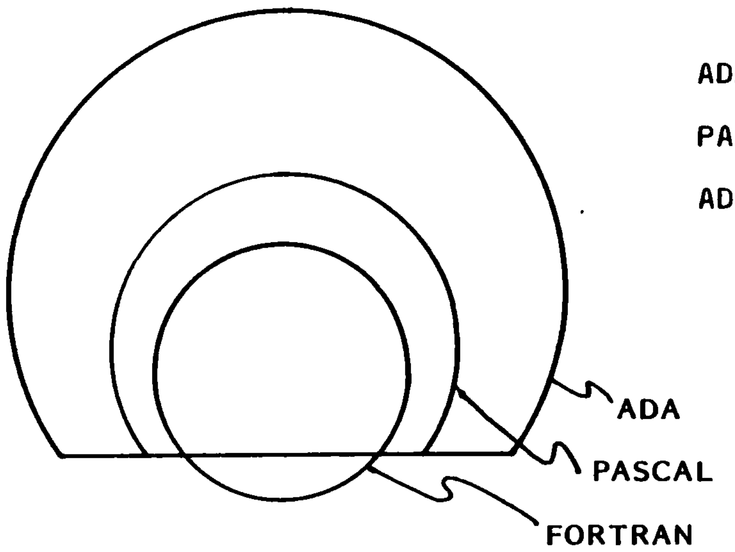
AGAIN, SOFTWARE ENGINEERING PRINCIPLES IMPLIES SUCH CONCEPTS AS STRUCTURED PROGRAMMING, STRONG TYPING OF DATA, MODULARITY, ABSTRACTION, READABILITY.

EMPHASIS OF ADA

- USEFUL FOR WIDE RANGE OF APPLICATIONS
    - EMBEDDED COMPUTER SYSTEMS
    - SYSTEMS PROGRAMMING
    - REAL TIME PROGRAMMING
    - DATA PROCESSING
- DEVELOPMENT BY PROJECT TEAMS
- SOFTWARE ENGINEERING PRINCIPLES ENCOURAGED AND ENFORCED
- MAINTAINABILITY AND RELIABILITY

INSTRUCTOR NOTES

COMPARISON WITH PASCAL AND FORTRAN



ROUGHLY SPEAKING:

ADA INCLUDES ALL OF PASCAL

PASCAL INCLUDES MOST OF FORTRAN

ADA INCLUDES MOST OF FORTRAN

- I/O FORMATTING IS MORE PRIMITIVE IN ADA AND PASCAL

INSTRUCTOR NOTES

COMPARISON WITH FORTRAN/PASCAL

ASPECTS NEW TO FORTRAN (NOT PASCAL)

MORE DATA TYPES

THE CONCEPT OF DATA TYPE

NO IMPLICIT DECLARATIONS

RICHER CONTROL STRUCTURES

INSTRUCTOR NOTES

FORTRAN COMPARISON

DIFFERENCES FROM FORTRAN (NOT PASCAL)

DATA TYPES

- PLAY A MORE CENTRAL ROLE IN ADA
- MORE TYPES
  - ENUMERATION TYPES
  - RECORD TYPES (INCLUDING VARIANTS)
  - ACCESS TYPES (POINTERS)

EXPLICIT DECLARATIONS REQUIRED

- READABILITY
- CATCHES ERRORS

MORE CONTROL STRUCTURES

- CASE STATEMENT

INSTRUCTOR NOTES

FORTRAN COMPARISON: DATA TYPES

- VALUES, E.G., Mon, Wed

- OPERATIONS, E.G. Mon < Y
  Mon + Wed -- ILLEGAL

- CONSTRAINTS - RESTRICT VALUES, NOT OPERATIONS
  range Mon .. Fri

CAN DEFINE NEW, PROBLEM-ORIENTED DATA TYPES IN ADA

INSTRUCTOR NOTES

FORTRAN COMPARISON: DATA TYPES

```
ENUMERATION TYPES                 VALUES

          type Day is (Mon, Tue, Wed, Thu, Fri, Sat, Sun);
          subtype Workday is Day range Mon .. Fri;
                                        CONSTRAINT

Today : Day := Sat;
    Y : Workday := 3;        -- ILLEGAL; NOT VALUE OF TYPE DAY
Holiday : Workday := Today;  -- EXCEPTION; CONSTRAINT NOT SATISFIED
     ... Mon + Today         -- ILLEGAL OPERATION
```

- MORE READABLE
- ERRORS ARE CAUGHT
- REQUIRES ADVANCE PLANNING TO CREATE TYPES THAT MEET YOUR NEEDS

INSTRUCTOR NOTES

FORTRAN COMPARISON: RECORD TYPE

```
type Months is (Jan, Feb, Mar, Apr, May ... Dec);

type Date is
   record
      Month : Months;
      Day   : Integer range 1 .. 31;
      Year  : Integer range 1800 .. 2500;
   end record;

X : Date := (Nov, 5, 1981);

Y : Date := (Year => 1901, Month => Nov, Day => 5);

if Y.Year > 1940 then ...
```

INSTRUCTOR NOTES

FORTRAN COMPARISON: CONTROL STRUCTURES

```
if Today = Thu then                 -- IN FORTRAN 77
       ...
else
       ...
end if;

case Today is                       -- NOT IN FORTRAN 77
       when Mon .. Thu => Work;
       when Fri => Work; Celebrate;
       when Sat|Sun => Rest; -- when others => Rest;
end case;
```

- FULL SET NEEDED FOR STRUCTURED PROGRAMMING

INSTRUCTOR NOTES

DIFFERENCES FROM PASCAL

* PACKAGES

- DATA
- TYPES
- OPERATIONS (SUBROUTINES)
- PRIVATE TYPES (PORTABILITY; ABSTRACTION)

* SEPARATE COMPILATION (WITH INTERFACE CHECKING)

* CONCURRENT AND REALTIME PROCESSING

REPRESENTATION CONTROL - *SPACE EFFICIENCY*

- PACK DATA
- CONFORM TO EXTERNAL INTERFACES

LOW LEVEL -- ACCESS TO MACHINE ARCHITECTURE

- MACHINE CODE

GENERIC UNITS

- ENHANCE REUSABILITY

EXCEPTION CONDITIONS

FIXED-POINT ARITHMETIC

INSTRUCTOR NOTES

ALLOW 15 MINUTES FOR THIS SECTION.

Section 7

For More Information

INSTRUCTOR NOTES

TOPIC OUTLINE

BACKGROUND AND RATIONALE FOR ADA

WRITING AN ADA PROGRAM FROM BEGIN TO END

SUMMARY OF ADA PROGRAM STRUCTURE

ADA THROUGH EXAMPLE

LARGE SYSTEM DEVELOPMENT

SUMMARY OF ADA FEATURES

FOR MORE INFORMATION

INSTRUCTOR NOTES

ADA/JUG IS A USER-ORIENTED GROUP WITH TOP DEFENSE CONTRACTORS, IMPLEMENTORS, EDUCATORS, GOVERNMENT OFFICIALS (AF, AJPO) MEETING TO EXCHANGE CURRENT STATUS, CONCERNS, NEW IDEAS.

SIGADA HAS MORE OF AN IMPLEMENTORS, RESEARCH BENT.

ADA LETTERS IS A PUBLICATION OF THE SPECIAL ADA INTEREST GROUP OF THE ACM.

FOR MORE INFORMATION

- ADA - JOVIAL USERS GROUP (ADAJUG)
- SIGADA
- ADA LETTERS
- ADA JOINT PROGRAM OFFICE (AJPO)
- ARPANET
- SEMINARS
- BOOKS

INSTRUCTOR NOTES

ADA JUG

LANGUAGE CONTROL FACILITY

CAROLE STEELE
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WRIGHT-PATTERSON AFB, OH 45433

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INSTRUCTOR NOTES

SIGADA AND ADA LETTERS

SIGADA: TECHNICAL STUDY GROUP OF THE ACM

ADA LETTERS: SIGADA PUBLICATION

FOR MEMBERSHIP IN ACM SIGADA

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INSTRUCTOR NOTES

AJPO

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Material: Ada Technical Overview (L102)

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1. Your name, company or affiliation, address and phone number.

2. Was the material accurate and technically correct?

Yes □ No □

Comments:

3. Were there any typographical errors?

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If yes, on what pages?

4. Was the material organized and presented appropriately for your applications?

Yes □ No □

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